APPENDIX D

Time to Clean Estimates for Chlorobenzene and 1,4-Dichlorobenzene

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TECHNICAL MEMORANDUM

To: Mr. Steve Smith, Solutia Inc.

From: Shahla Farhat, James Kearley, and Charles Newell

Re: **Time to Clean Estimates for Chlorobenzene and 1,4-Dichlorobenzene**
Sauget Area 1, Sauget and Cahokia, Illinois

As requested by Solutia Inc. (Solutia), GSI Environmental Inc. (GSI) used the regional groundwater flow and transport model for the American Bottoms Aquifer (GSI, 2008) to develop time to clean estimates for chlorobenzene (CB) and 1,4-dichlorobenze (1,4-DCB) in groundwater at a hypothetical observation well located approximately halfway between the Sauget Area 1 (SA1) sources and the Mississippi River.

ESTIMATED MASS REMOVAL RATE DUE TO REMEDIATION

The SA1 Feasibility Study will include evaluation of a technology for source mass reduction in areas where residual DNAPL is present within the Middle Hydrogeologic Unit (MHU) and Deep Hydrogeologic Unit (DHU). The technologies currently being considered for source mass reduction include i) air sparging with soil vapor extraction and ii) pulsed air bio-sparging.

The outcomes for source mass removal at SA1 using these technologies cannot be estimated precisely but are likely to be bracketed between 75% and 90% mass reduction, based on review of various studies (Brown et al., 1998; Machackova; Sale et al., 2008; Sperry et al., 2001). Therefore, time to clean was estimated using 75% and 90% source mass reduction. At USEPA's request, time to clean was also estimated using an assumed 50% source mass reduction. For the purpose of this modeling study, it was assumed that the source mass remediation projects would be completed by 2015, to allow several years for approval and implementation of a technology.

MODEL SIMULATIONS TO ESTIMATE TIME TO CLEAN

The Regional Groundwater Flow and Contaminant Transport Model (GSI, 2008) was used to perform model simulations to estimate time to clean for CB and 1,4-DCB. Appendix A includes a general description of the model, six figures to illustrate CB and 1,4-DCB source concentrations used in the time to clean simulations, and a summary of model limitations. Historical and future source concentrations in the Regional Transport Model were estimated by projecting source concentrations backward and forward in time assuming a conservative first-order source decay half-life of 40 years. This source decay rate was based on median values calculated for the MHU and DHU in the *Sauget Area 2 Focused Feasibility Study* (GSI, 2003) and *Source Evaluation Study, Sauget Area 1* (GSI, 2001).

The existing Regional Transport Model was used to estimate the time to clean for four scenarios:
1) monitored natural attenuation (MNA) with no source area treatment;
2) MNA with an assumed source mass reduction of 50% that occurs in 2015;
3) MNA with an assumed source mass reduction of 75% that occurs in 2015; and
4) MNA with an assumed source mass reduction of 90% that occurs in 2015.

These scenarios were modeled with these key considerations:

- The MODFLOW and MT3D models were run under transient conditions from 1960 to 2100.

- Only SA1 sources were used in the simulations (see Figures A-1 through A-6). Future source concentrations were estimated by projecting source concentrations forward in time assuming a conservative first-order source decay half-life of 40 years (GSI, 2008).

- An observation well screened in the SHU, MHU, and DHU was placed approximately 2300 feet downgradient of Site I, midway between the SA1 sources and the Mississippi River. Model concentrations at the observation well were determined for 2006, 2010, 2015, 2020, and then every 10 years until 2100. Note that the model calibration resulted in model concentrations being closer to actual measured concentrations in some areas and zones, and farther away in others. At the selected observation well, the DHU modeled data compare well to the actual data in 2006, while the MHU data are farther apart. See Appendix B for a more detailed discussion.

The time to clean estimates relied on these three assumptions:

1) The sources in the Regional Transport Model decay slowly over time based on a first order decay relationship (see section 4.9 of the Regional Transport Model report, GSI, 2008). This is the same approach used in the USEPA groundwater models BIOSCREEN, BIOCHLOR, and REMChlor;
2) The concentration in groundwater downgradient of a source area is proportional to source mass (Falta et al, 2005a,b; Falta, et al., 2006);
3) Source mass removal of 50%, 75% or 90% is complete by the year 2015 at the DNAPL source areas located at Sites G, H, and I. The year 2015 was selected to allow several years for approval and implementation of a source treatment remedy.

Figures 1 to 4 plot the log of modeled concentrations of CB and 1,4-DCB vs. time in the MHU and DHU at the hypothetical observation well.

Key Features of Concentration vs. Time Graph

Key features of the concentration vs. time predications shown in Figures 1 to 4 are discussed below.

- *Stops at Year 2100:* The model run was stopped at year 2100 because of the long time to run the model and file size.

  Apparent Increase Between 2010 and 2015: The apparent increases in the modeled concentrations of CB and 1,4-DCB between 2006 and 2015 are due to changing groundwater flow directions over time. In the early 2000s, the SA1 plumes are oriented more north/south due to the influence of the Highway Dewatering System in East St. Louis (see Figures 32 and 33 in GSI, 2008). Since this Highway Dewatering System's estimated flowrate was reduced significantly in the model in 2000, and then set to zero in 2010 (based on information that this system would be shut down in 2010), the SA1 plume then takes a more westerly direction towards the river and results in an increase in concentration over time at the hypothetical observation well. By the time the system reaches steady state (about 2020), the concentration will be decreasing steadily due to the effects of source decay and will continue to decrease as the source is depleted. (see GSI, 2008, "Mass Flux Discussion" in Section 6.4).

- *Source Decay Continues after Remediation:* Source decay from groundwater flushing continues to occur after source remediation.   Future source concentrations were estimated by projecting source concentrations forward in time assuming the same conservative first-order source decay half-life of 40 years (GSI, 2008).

Extrapolations Beyond Year 2100

The time-to-clean estimates were based on extrapolation of the modeled concentration trend lines as shown on Figures 1 to 4. The MCLs for CB and 1,4-DCB are 100 ug/L and 75 ug/L, respectively.

TIME TO CLEAN RESULTS WITH AND WITHOUT SOURCE REMEDIATION

The following tables summarize modeled time to clean results at the observation well for the three scenarios.   Table 1 lists the calendar years in which groundwater concentrations achieve MCLs at the observation well, as shown on Figures 1 through 4. Table 2 lists time to clean estimates for the observation well. On Table 2, time to clean is defined as the number of years to reach MCLs at the observation well after the year 2015, which is when the source reduction treatment is assumed to have achieved the source reduction of 50%, 75% or 90%.

Table 1 – Calendar Year that Concentrations Achieve MCLs

	MNA Only (Calendar Year)	MNA with 50% Source Reduction (Calendar Year)	MNA with 75% Source Reduction (Calendar Year)	MNA with 90% Source Reduction (Calendar Year)
Chlorobenzene				
MHU	2307	2267	2230	2174
DHU	2294	2254	2217	2161
1,4-Dichlorobenzene				
MHU	2184	2142	2100	2045
DHU	2187	2145	2103	2048

Table 2 – Calculated Time to Clean in Years after 2015
(i.e., after date of source remediation)

	MNA Only (years after 2015)	MNA with 50% Source Reduction (years after 2015)	MNA with 75% Source Reduction (years after 2015)	MNA with 90% Source Reduction (years after 2015)
Chlorobenzene				
MHU	292	252	215	159
DHU	279	239	202	146
1,4-Dichlorobenzene				
MHU	169	127	85	30
DHU	172	130	88	33

As discussed in Attachment B, the model over predicts the time to clean for the MHU at the hypothetical observation well, based on comparison with observed concentrations in the MHU at a monitoring well at approximately the same location as the hypothetical observation well.

There is considerable uncertainty in the calculated time to clean results. The following table shows the calculated results rounded to the nearest ten years and the estimated range for time to clean when an uncertainty factor of +/- 2 is applied.

**Table 3 – Time to Clean Results and Estimated Range in Years after 2015
(i.e., after date of source remediation)**

	MNA Only (years after 2015)	MNA with 50% Source Reduction (years after 2015)	MNA with 75% Source Reduction (years after 2015)	MNA with 90% Source Reduction (years after 2015)
Chlorobenzene				
MHU	290	250	220	160
	150-580	130-500	110-440	80-320
DHU	280	240	200	150
	140-560	120-480	100-400	80-300
1,4-Dichlorobenzene				
MHU	170	130	90	30
	90-340	70-260	50-180	20-60
DHU	170	130	90	30
	90-340	70-260	50-180	20-60

1) Estimates are rounded to the nearest ten years.

REFERENCES

Aziz, C.E., C.J. Newell, J.R. Gonzales, P.E. Haas, T.P. Clement, and Y. Sun, 2000. BIOCHLOR Natural Attenuation Decision Support System, User's Manual Version 1.1, United States Environmental Protection Agency, Office of Research and Development, EPA/600/R-00/008, www.epa.gov/ada/csmos/models.html.

Brown, R.A., Bass, D.H., Clayton, W., 1998. "An Analysis of Air Sparging for Chlorinated Solvent Sites", in Physical, Chemical, and Thermal Technologies – Remediation of Chlorinated and Recalcitrant Compounds, edited by G. B. Wickramanayake and R. E. Hinchee, Battelle Press, 1998.

Falta R.W., P.S. Rao, and N. Basu, 2005a. Assessing Impacts of Partial Mass Depletion in DNAPL Source Zones: I. Analytical Modeling of Source Strength Functions and Plume Response, *J. Cont. Hydrology*, 78: 259-280, 2005.

Falta R.W., N. Basu, and P.S. Rao, 2005b. Assessing Impacts of Partial Mass Depletion in DNAPL Source Zones: II. Coupling Source Strength Functions to Plume Evolution, *J. Cont. Hydrology*, 79: 45-66, 2005.

Falta R.W., M.B. Stacy, A.N.M. Ahsanuzzaman, M. Wang, et al., 2006. "REMChlor Rmediation Evaluation Model for Chlorinated Solvents", User's Manual, October 2, 2006.

Groundwater Services, Inc.,2001. "Source Evaluation Study, Sauget Area 1", Prepared for Solutia Inc. by Groundwater Services, Inc., May 21, 2001.

Groundwater Services, Inc., 2003. "Sauget Area 2 Focused Feasibility Study", Prepared for URS Corp. by Groundwater Services, Inc., November 20, 2003.

GSI Environmental Inc., 2008. "Regional Groundwater Flow and Contaminant Transport Model, American Bottoms Aquifer", Prepared for URS Corp. by GSI Environmental Inc., April 14, 2008.

Machackova J., et al. In Situ Bioremediation of Petroleum Hydrocarbons at the Former Solviet AFB Hradcany. Czech Ministry of Environment, Czech Republic.

Newell, C.J. and D.T. Adamson, 2004. "Planning-level source decay models to evaluate impact of source depletion on remediation timeframe", Submitted to Environmental Science and Technology, October 2004.

Sale, T., Newell, C, Stroo, H., Hinchee, R., and Johnson, P., 2008. "Frequently Asked Questions Regarding Management of Chlorinated Solvents in Soils and Groundwater," developed for ESTCP, July 2008.

Solutia, 2002, "Focused Feasibility Study Interim Groundwater Remedy Sauget Area 2 Sites O, Q, R, and S," Solutia, Inc., March 31, 2002.

Solutia, 2005, "Interim Operating Period 1 Tech Memo," Solutia, Inc., April 1, 2005.

Sperry et al. Field Trial of Biosparging with Oxygen for Bioremediation of Volitile Organic Compounds. Remediation, Autumn 2001.

URS Corporation, 2004. "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.

GSI Job No. G-3450
Issued: 13-November-09

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TIME TO CLEAN ESTIMATES
Sauget Area 1, Sauget, Illinois

FIGURES

FIGURE 1.
Chlorobenzene in Groundwater 2320 ft Downgradient of Site I
Middle Hydrogeologic Unit (MHU), Sauget, Illinois

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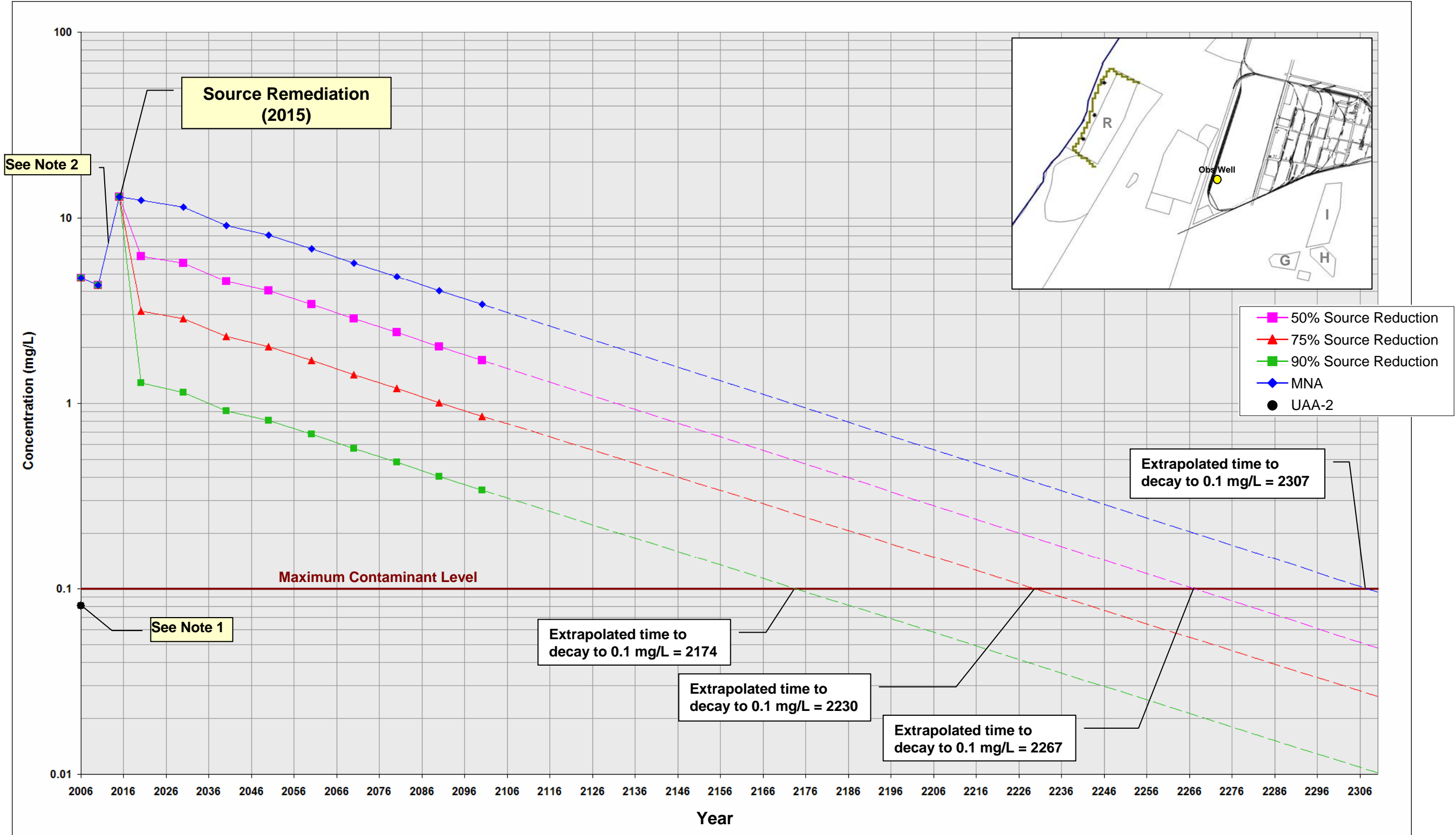
Notes:
1.   Observed concentration in 2006 at location UAA-2.
2.   Increase in concentration due to change in plume centerline due to shut-off of highway dewatering wells in 2010.
3.   Dashed lines represent extrapolations.

FIGURE 2.
Chlorobenzene in Groundwater 2320 ft Downgradient of Site I
Deep Hydrogeologic Unit (DHU), Sauget, Illinois

GSI Job No: G-3450
Date Issued: 13-Nov-09
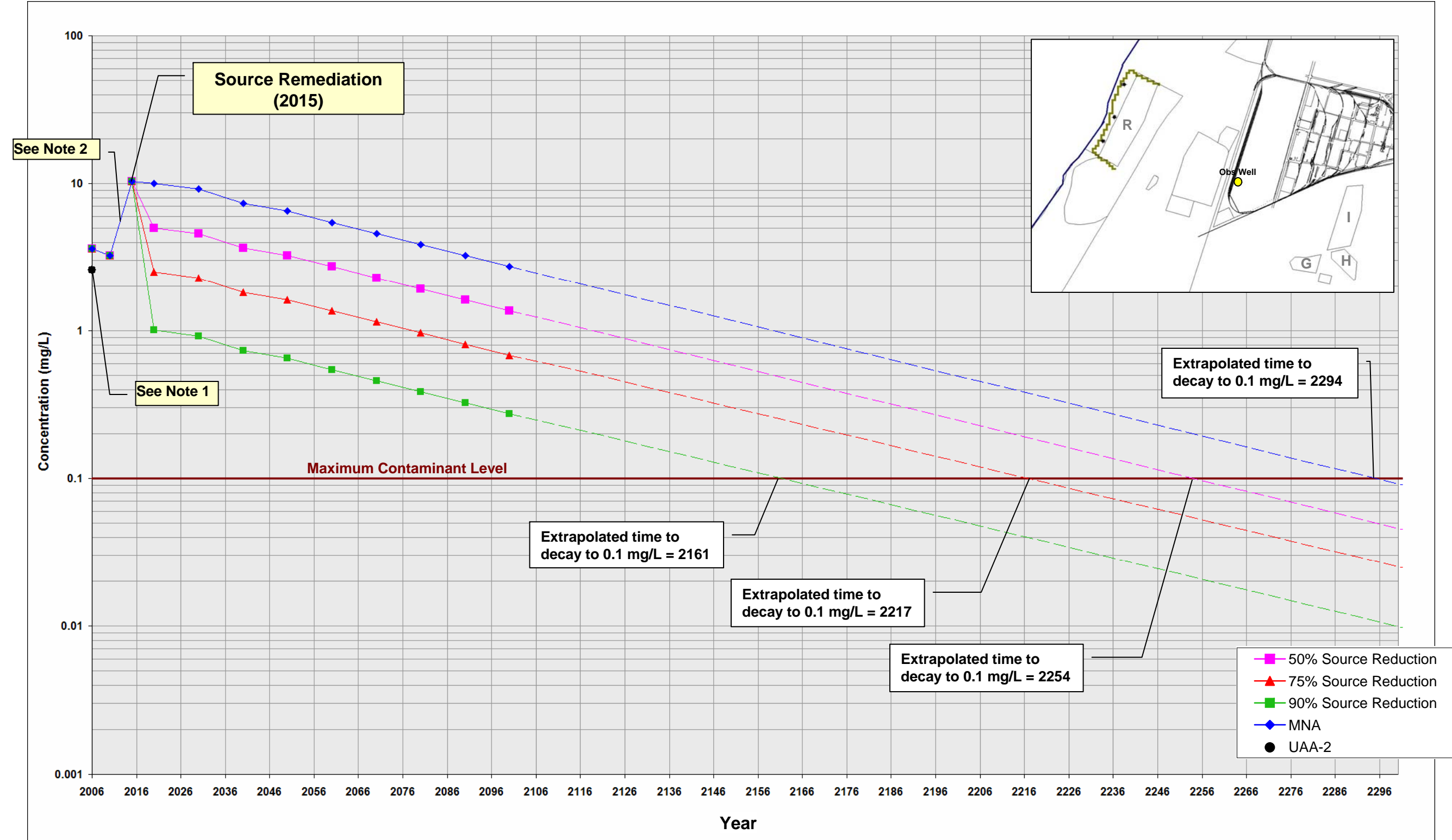
Notes:
1. Observed concentration in 2006 at location UAA-2.
2. Increase in concentration due to change in plume centerline due to shut-off of highway dewatering wells in 2010.
3. Dashed lines represent extrapolations.

FIGURE 3.
1,4-Dichlorobenzene in Groundwater 2320 ft Downgradient of Site I
Middle Hydrogeologic Unit (MHU), Sauget, Illinois

GSI Job No: G-3450
Date Issued: 13-Nov-09

Notes:
1. Observed concentration in 2006 at location UAA-2.
2. Increase in concentration due to change in plume centerline due to shut-off of highway dewatering wells in 2010.
3. Dashed lines represent extrapolations.

FIGURE 4.
1,4-Dichlorobenzene in Groundwater 2320 ft Downgradient of Site I
Deep Hydrogeologic Unit (DHU), Sauget, Illinois

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Date Issued: 13-Nov-09

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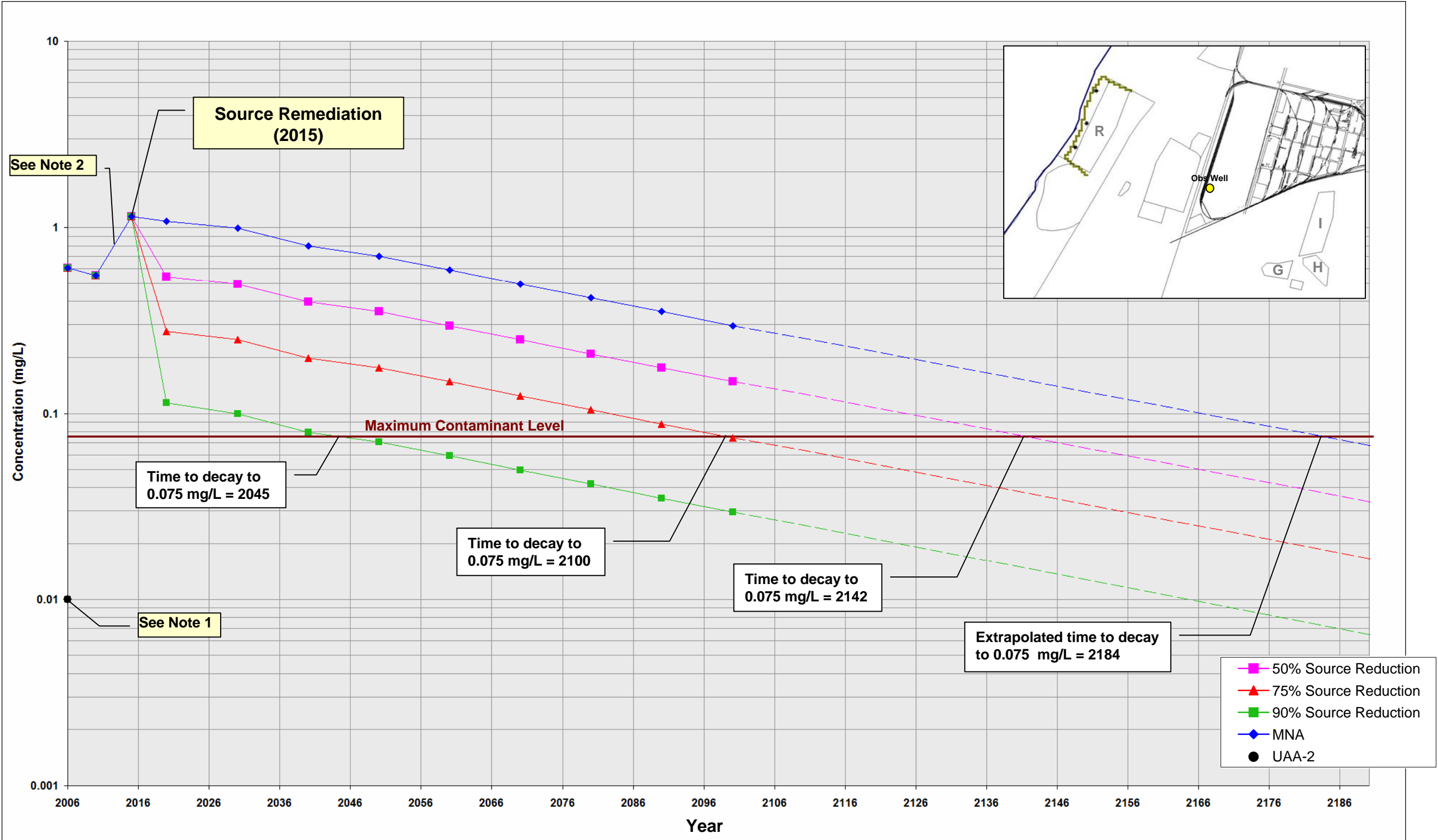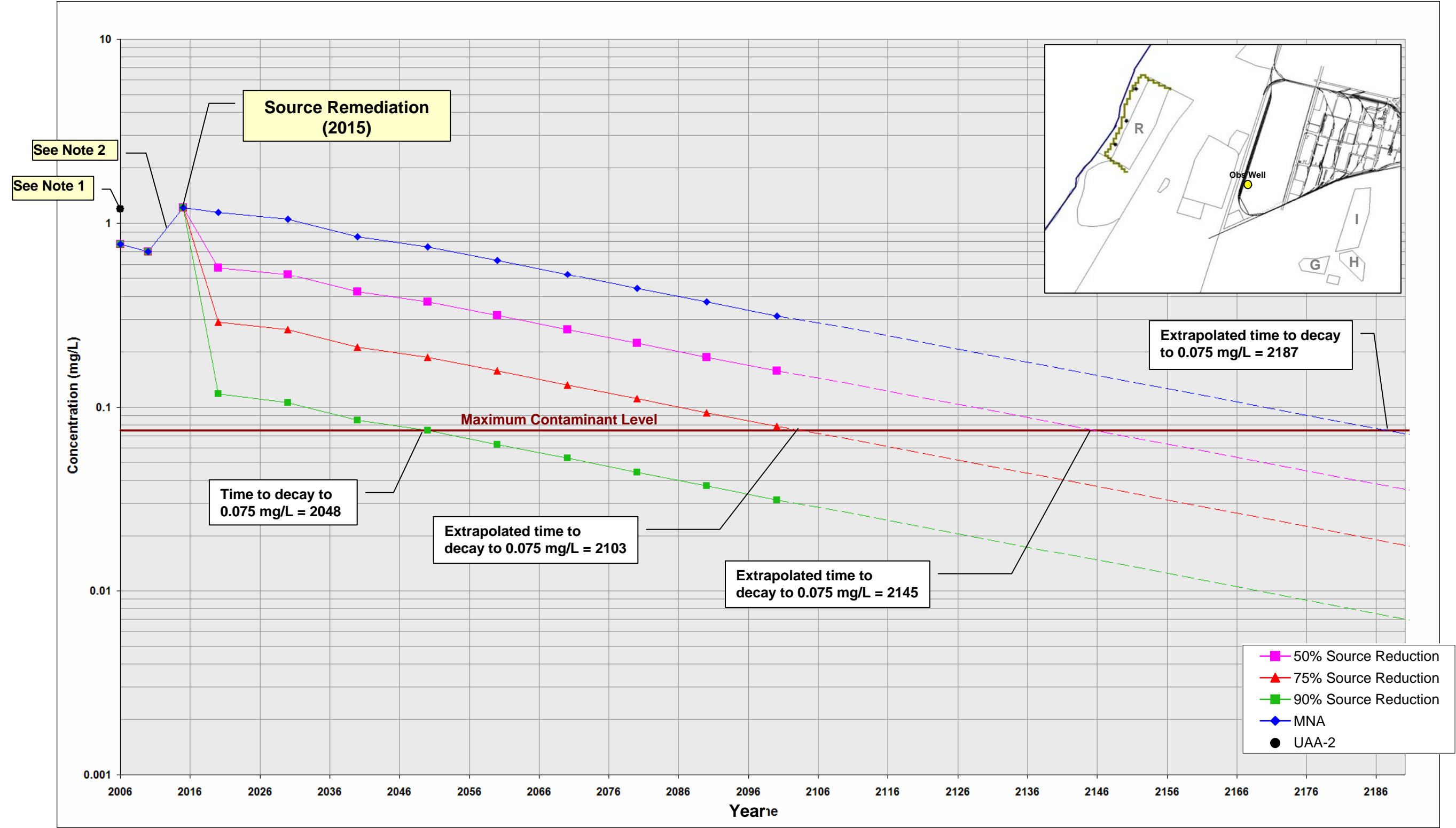**Notes:**
1. Observed concentration in 2006 at location UAA-2.
2. Increase in concentration due to change in plume centerline due to shut-off of highway dewatering wells in 2010.
3. Dashed lines represent extrapolations.

TIME TO CLEAN ESTIMATES
Sauget Area 1, Sauget, Illinois

APPENDIX A
MODEL DESCRIPTION, LIMITATIONS, AND REFERENCES

Model Description, Limitations, and References

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MODEL DESCRIPTION, LIMITATIONS, AND REFERENCES

Sauget Area 1, Sauget and Cahokia, Illinois

As requested by Solutia, GSI used the regional groundwater flow and transport model for the American Bottoms Aquifer (GSI, 2008) to develop time to clean estimates for chlorobenzene and 1,4-dichlorobenze in groundwater at a hypothetical observation well located approximately halfway between the SA1 sources and the Mississippi River.

GROUNDWATER MODEL DESCRIPTION

The model is described in detail in the *Regional Groundwater Flow and Contaminant Transport Model* (GSI, 2008). Key model attributes, assumptions, and input data for the groundwater model are listed below:

- A non-uniform finite-difference grid with 60 ft by 60 ft cells in the vicinity of the SA2 GMCS was used with cell size gradually increasing with distance from Site R. Adjacent model cell column and row widths were not altered more than a factor of 1.5 (ASTM D 5880-95). This type of variable-size grid provides a good balance between simulation accuracy and run time.

- Three layers were used in the model: i) an unconfined Shallow Hydrogeologic Unit (SHU) with a porosity of 0.30; ii) a convertible confined/unconfined Middle Hydrogeologic Unit (MHU); and iii) a confined Deep Hydrogeologic Unit (DHU). Geologic descriptions and hydraulic conductivity data indicate that the SHU can serve as a semi-confining layer for the deeper hydrogeologic units. No aquitards restrict vertical groundwater flow between the MHU and DHU.

- A horizontal hydraulic conductivity of 5×10^{-3} cm/sec was used for the SHU. Hydraulic conductivity data compiled by Schicht (1965) were used for the MHU and DHU.

- Bedrock elevations, which form the bottom of the lowest layer (DHU, Layer 3 in the model), were established by Kriging data contained in Bergstrom and Walker (Figure 2 in Bergstrom and Walker, 1956), results from a small-area geophysical study of an area near the Krummrich facility, and available boring log data.

- The Mississippi River was modeled using MODFLOW's river package. The areal extent of the river was obtained from USGS topographic maps and URS figures. Each river cell was assigned a river stage (assumed constant for all river cells in the model), river bottom elevation (based on U.S. Corps of Engineers bathymetric cross sections), and a conductance term. An average river level stage of 390.12 ft MSL was used for the river in the study area.

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- Constant head cells were used in the model to represent the eastern boundary of the modeled area (the bluff line) based on "steady-state" constant head elevations used in a regional groundwater flow model developed by Clark (1997).

- A surface infiltration rate of 7.8 inches per year was used in the model to represent infiltration from rainfall.

- A regional pumping center of 6828 gpm, assumed to be withdrawn from all three layers, was established in the model to represent ongoing highway dewatering projects in the East St. Louis area.

- Based on personal communication with Solutia, highway de-watering pumping was assumed to terminate in 2010 due to planned road construction projects.

- The GMCS was incorporated into the model. The GMCS system consists of a "U"-shaped slurry wall (3 ft wide, 3,300 ft long, 140 ft deep) (Solutia, 2002; URS, 2004) located between Sauget Area 2 Site R and the Mississippi River and three groundwater extraction wells between the slurry wall and Site R. A hydraulic conductivity of 1.4×10^{-8} cm/sec (Solutia, 2005) was used for the slurry wall extending from the SHU to the DHU in the model. The slurry wall was modeled using MODFLOW's Horizontal Flow Barrier package.

- Source concentrations were based on data provided by Solutia and the database developed for the *Regional Groundwater Flow and Contaminant Transport Model* (See Figures A-1 to A-6 for source concentrations at SA1 that were used in the time-to-clean evaluation).

- Historical and future source concentrations were estimated by projecting source concentrations backward and forward in time assuming a conservative first-order source decay half-life of 40 years. This source decay rate was based on median values calculated for the MHU and DHU in the *Sauget Area 2 Focused Feasibility Study* (GSI, 2003a) and *Source Evaluation Study* (GSI, 2001).

- The individual rates (biodegradation rate = ln(2)/half-life) used in the calibrated model are presented below:

Constituent	Biodegradation Rate Constant (day^{-1})		
	SHU	MHU	DHU
1,4-Dichlorobenzene	0.0019	0.0019	0.0019
Chlorobenzene	0.0023	0.0015	0.0023

MODEL LIMITATIONS

The groundwater flow and contaminant transport models have the following key limitations:

- Variations in Shallow Hydrogeologic Unit are not incorporated into the flow model; the unit is assumed to have a constant hydraulic conductivity.

- The Mississippi River is simulated with idealized cross section and river bottom conductance values that do not account for local variability of river conductance.

- The contaminant transport model has difficulty matching observed concentrations in wells immediately adjacent to the GMCS and Site R.

- The pumping rates for the industrial and highway dewatering are constant rates, when in actuality, the rates likely varied substantially over the duration of the simulations.

- Only one parameter was changed at a time during the sensitivity analysis, and therefore the modeling analysis does not account for any combined effects of parameters that might have changed.

- Source decay for all constituents was treated as a generalized term based on data derived from chlorobenzene source zones.

REFERENCES

American Society for Testing and Materials, 2000. "Standard Guide for Subsurface Flow and Transport Modeling", ASTM D 5880-95, Philadelphia, PA.

Bergstrom, R.E. and T.R. Walker, 1956. *Groundwater Geology of the East St. Louis Area, Illinois*, Illinois State Geological Survey, Urbana, Illinois.

Clark, G.R., 1997. *American Bottoms Regional Ground-Water Flow Model*, Illinois Department of Natural Resources, Office of Water Resources, Springfield, Illinois.

Groundwater Services, Inc., "Source Evaluation Study, Sauget Area 1", Prepared for Solutia Inc. by Groundwater Services, Inc., May 21, 2001.

Groundwater Services, Inc., "Sauget Area 2 Focused Feasibility Study", Prepared for URS Corp. by Groundwater Services, Inc., November 20, 2003.

GSI Environmental Inc., "Regional Groundwater Flow and Contaminant Transport Model, American Bottoms Aquifer", Prepared for URS Corp. by GSI Environmental Inc., April 14, 2008.

McDonald, M.G. and A. Harbaugh, 1988. *A Modular Three Dimensional Finite-Difference Groundwater Flow Model*, Techniques of Water Resources Investigations 06-A7, USGS.

Pollock, D.W., 1998. *MODPATH, Documentation Of Computer Programs To Compute and Display Pathlines Using Results from U.S. Geological Survey Modular Three-*

Dimension Finite Difference Groundwater Flow Model, U.S. Geological Survey Open Report 89-381.

Schicht, R.J., 1965. *Ground-Water Development in East St. Louis Area, Illinois, Report of Investigation 51*, Illinois State Water Survey, Urbana, Illinois.

Solutia, 2002, "Focused Feasibility Study Interim Groundwater Remedy Sauget Area 2 Sites O, Q, R, and S," Solutia, Inc., March 31, 2002.

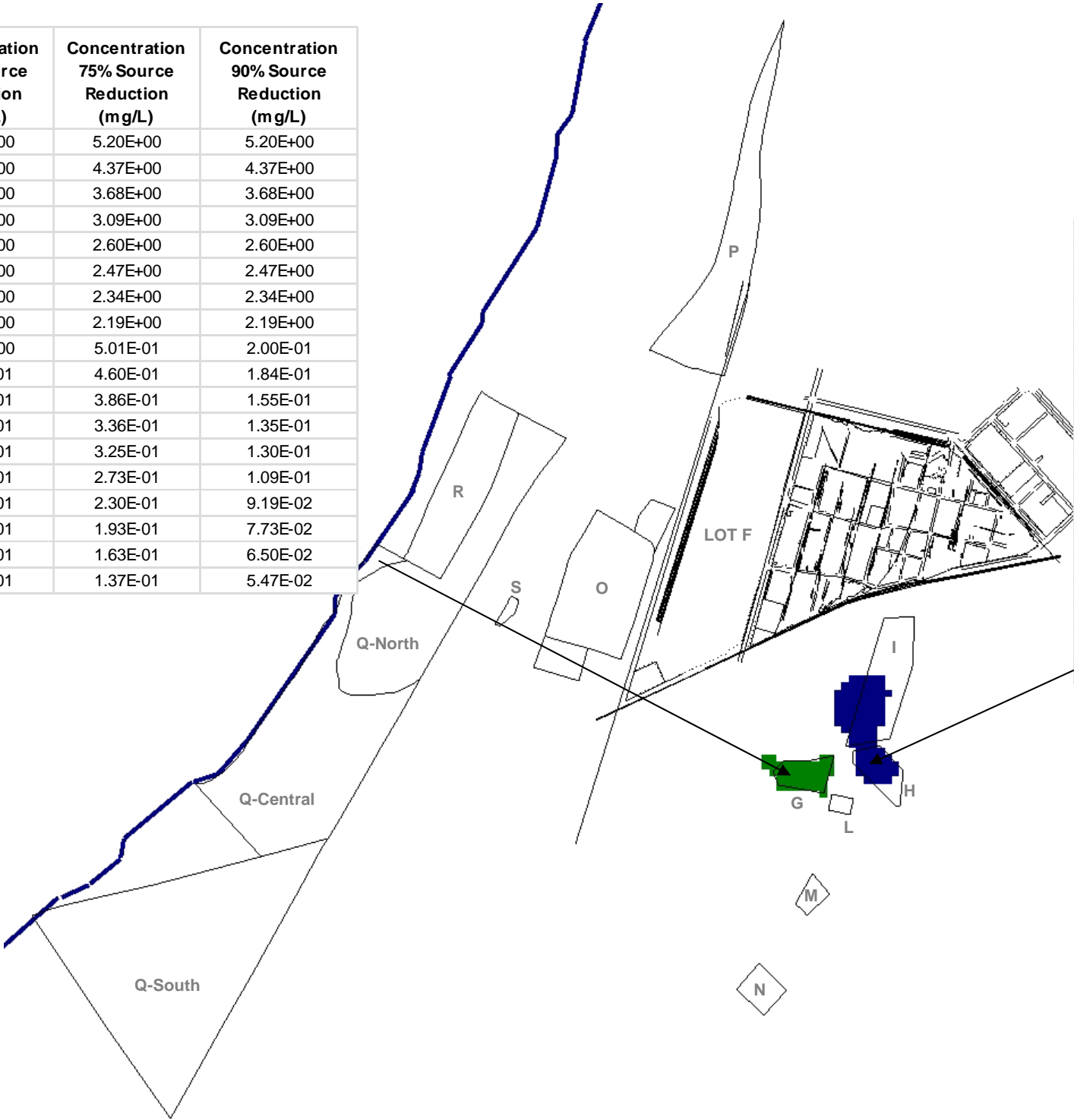Solutia, 2005, "Interim Operating Period 1 Tech Memo," Solutia, Inc., April 1, 2005.

URS Corporation, 2004. "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.

FIGURE A.1
Chlorobenzene Source Areas and Concentrations
Shallow Hydrogeologic Unit (Layer 1 in Model)

Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	5.20E+00	5.20E+00	5.20E+00	5.20E+00
6/1/1970	6/1/1980	4.37E+00	4.37E+00	4.37E+00	4.37E+00
6/1/1980	6/1/1990	3.68E+00	3.68E+00	3.68E+00	3.68E+00
6/1/1990	6/1/2000	3.09E+00	3.09E+00	3.09E+00	3.09E+00
6/1/2000	6/1/2003	2.60E+00	2.60E+00	2.60E+00	2.60E+00
6/1/2003	6/1/2006	2.47E+00	2.47E+00	2.47E+00	2.47E+00
6/1/2006	6/1/2010	2.34E+00	2.34E+00	2.34E+00	2.34E+00
6/1/2010	6/1/2015	2.19E+00	2.19E+00	2.19E+00	2.19E+00
6/1/2015	6/1/2020	2.00E+00	1.00E+00	5.01E-01	2.00E-01
6/1/2020	6/1/2030	1.84E+00	9.19E-01	4.60E-01	1.84E-01
6/1/2030	6/1/2038	1.55E+00	7.73E-01	3.86E-01	1.55E-01
6/1/2038	6/1/2040	1.35E+00	6.73E-01	3.36E-01	1.35E-01
6/1/2040	6/1/2050	1.30E+00	6.50E-01	3.25E-01	1.30E-01
6/1/2050	6/1/2060	1.09E+00	5.47E-01	2.73E-01	1.09E-01
6/1/2060	6/1/2070	9.19E-01	4.60E-01	2.30E-01	9.19E-02
6/1/2070	6/1/2080	7.73E-01	3.86E-01	1.93E-01	7.73E-02
6/1/2080	6/1/2090	6.50E-01	3.25E-01	1.63E-01	6.50E-02
6/1/2090	6/1/2100	5.47E-01	2.73E-01	1.37E-01	5.47E-02

Start Date	End Date	MNA	50%	75%	90%
6/1/1960	6/1/1970	3.20E-02	3.20E-02	3.20E-02	3.20E-02
6/1/1970	6/1/1980	2.69E-02	2.69E-02	2.69E-02	2.69E-02
6/1/1980	6/1/1990	2.26E-02	2.26E-02	2.26E-02	2.26E-02
6/1/1990	6/1/2000	1.90E-02	1.90E-02	1.90E-02	1.90E-02
6/1/2000	6/1/2003	1.60E-02	1.60E-02	1.60E-02	1.60E-02
6/1/2003	6/1/2006	1.52E-02	1.52E-02	1.52E-02	1.52E-02
6/1/2006	6/1/2010	1.44E-02	1.44E-02	1.44E-02	1.44E-02
6/1/2010	6/1/2015	1.35E-02	1.35E-02	1.35E-02	1.35E-02
6/1/2015	6/1/2020	1.23E-03	6.17E-03	3.08E-03	1.23E-03
6/1/2020	6/1/2030	1.13E-02	5.66E-03	2.83E-03	1.13E-03
6/1/2030	6/1/2038	9.51E-03	4.76E-03	2.38E-03	9.51E-04
6/1/2038	6/1/2040	8.28E-03	4.14E-03	2.07E-03	8.28E-04
6/1/2040	6/1/2050	8.00E-03	4.00E-03	2.00E-03	8.00E-04
6/1/2050	6/1/2060	6.73E-03	3.36E-03	1.68E-03	6.73E-04
6/1/2060	6/1/2070	5.66E-03	2.83E-03	1.41E-03	5.66E-04
6/1/2070	6/1/2080	4.76E-03	2.38E-03	1.19E-03	4.76E-04
6/1/2080	6/1/2090	4.00E-03	2.00E-03	1.00E-03	4.00E-04
6/1/2090	6/1/2100	3.36E-03	1.68E-03	8.41E-04	3.36E-04

N

P

R

LOT F

S

O

Q-North

Q-Central

Q-South

I

G

H

L

M

N

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
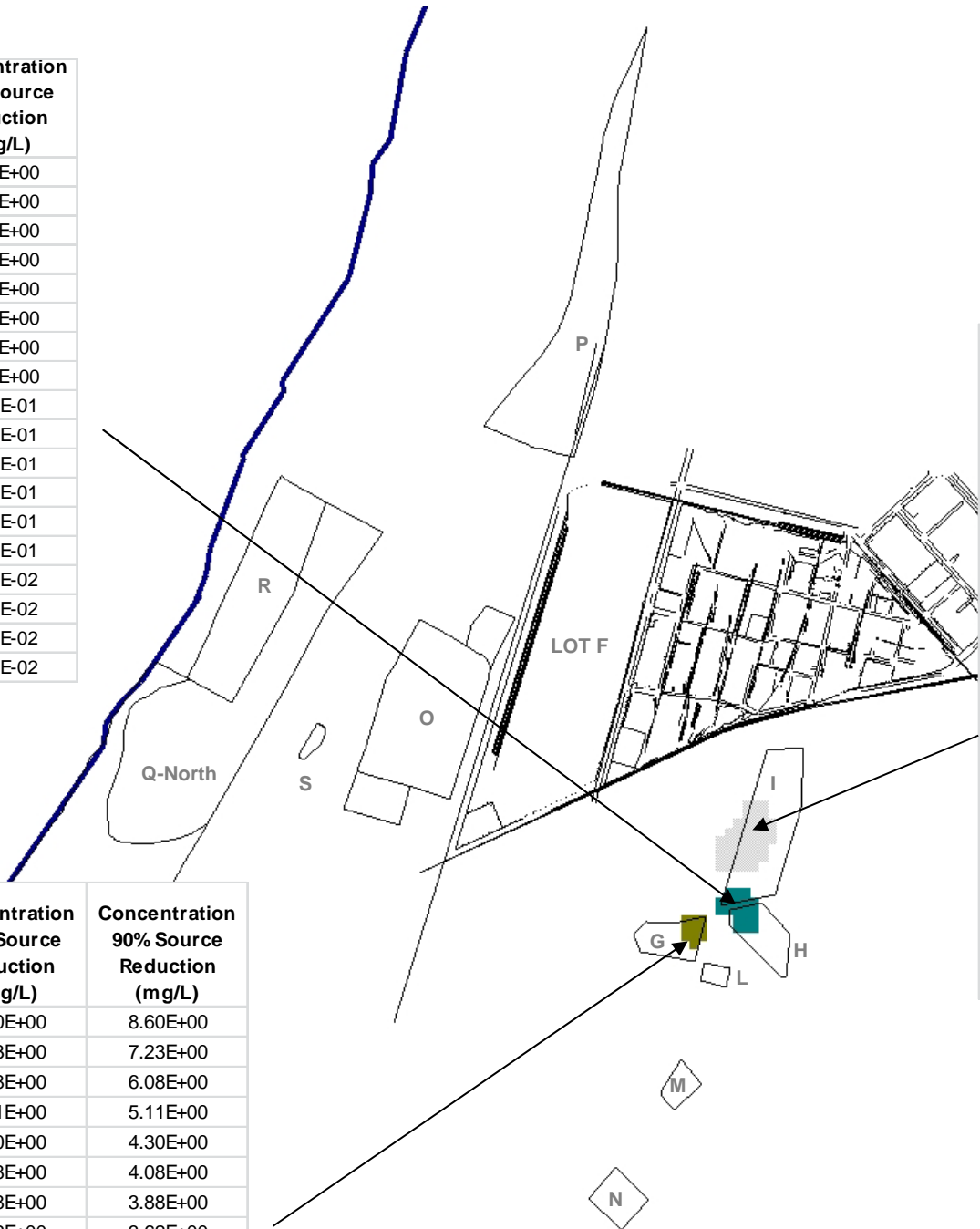3. Source reduction simulated in 2015.

FIGURE A.2
Chlorobenzene Source Areas and Concentrations
Middle Hydrogeologic Unit (Layer 2 in Model)

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	4.80E+00	4.80E+00	4.80E+00	4.80E+00
6/1/1970	6/1/1980	4.04E+00	4.04E+00	4.04E+00	4.04E+00
6/1/1980	6/1/1990	3.39E+00	3.39E+00	3.39E+00	3.39E+00
6/1/1990	6/1/2000	2.85E+00	2.85E+00	2.85E+00	2.85E+00
6/1/2000	6/1/2003	2.40E+00	2.40E+00	2.40E+00	2.40E+00
6/1/2003	6/1/2006	2.28E+00	2.28E+00	2.28E+00	2.28E+00
6/1/2006	6/1/2010	2.16E+00	2.16E+00	2.16E+00	2.16E+00
6/1/2010	6/1/2015	2.02E+00	2.02E+00	2.02E+00	2.02E+00
6/1/2015	6/1/2020	1.85E+00	9.25E-01	4.63E-01	1.85E-01
6/1/2020	6/1/2030	1.70E+00	8.49E-01	4.24E-01	1.70E-01
6/1/2030	6/1/2038	1.43E+00	7.14E-01	3.57E-01	1.43E-01
6/1/2038	6/1/2040	1.24E+00	6.21E-01	3.11E-01	1.24E-01
6/1/2040	6/1/2050	1.20E+00	6.00E-01	3.00E-01	1.20E-01
6/1/2050	6/1/2060	1.01E+00	5.05E-01	2.52E-01	1.01E-01
6/1/2060	6/1/2070	8.49E-01	4.24E-01	2.12E-01	8.49E-02
6/1/2070	6/1/2080	7.14E-01	3.57E-01	1.78E-01	7.14E-02
6/1/2080	6/1/2090	6.00E-01	3.00E-01	1.50E-01	6.00E-02
6/1/2090	6/1/2100	5.05E-01	2.52E-01	1.26E-01	5.05E-02

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	2.40E+02	2.40E+02	2.40E+02	2.40E+02
6/1/1970	6/1/1980	2.02E+02	2.02E+02	2.02E+02	2.02E+02
6/1/1980	6/1/1990	1.70E+02	1.70E+02	1.70E+02	1.70E+02
6/1/1990	6/1/2000	1.43E+02	1.43E+02	1.43E+02	1.43E+02
6/1/2000	6/1/2003	1.20E+02	1.20E+02	1.20E+02	1.20E+02
6/1/2003	6/1/2006	1.14E+02	1.14E+02	1.14E+02	1.14E+02
6/1/2006	6/1/2010	1.08E+02	1.08E+02	1.08E+02	1.08E+02
6/1/2010	6/1/2015	1.01E+02	1.01E+02	1.01E+02	1.01E+02
6/1/2015	6/1/2020	9.25E+01	4.63E+01	2.31E+01	9.25E+00
6/1/2020	6/1/2030	8.48E+01	4.24E+01	2.12E+01	8.49E+00
6/1/2030	6/1/2038	7.13E+01	3.57E+01	1.78E+01	7.14E+00
6/1/2038	6/1/2040	6.21E+01	3.11E+01	1.55E+01	6.21E+00
6/1/2040	6/1/2050	6.00E+01	3.00E+01	1.50E+01	6.00E+00
6/1/2050	6/1/2060	5.05E+01	2.52E+01	1.26E+01	5.05E+00
6/1/2060	6/1/2070	4.24E+01	2.12E+01	1.06E+01	4.24E+00
6/1/2070	6/1/2080	3.57E+01	1.78E+01	8.92E+00	3.57E+00
6/1/2080	6/1/2090	3.00E+01	1.50E+01	7.50E+00	3.00E+00
6/1/2090	6/1/2100	2.52E+01	1.26E+01	6.31E+00	2.52E+00

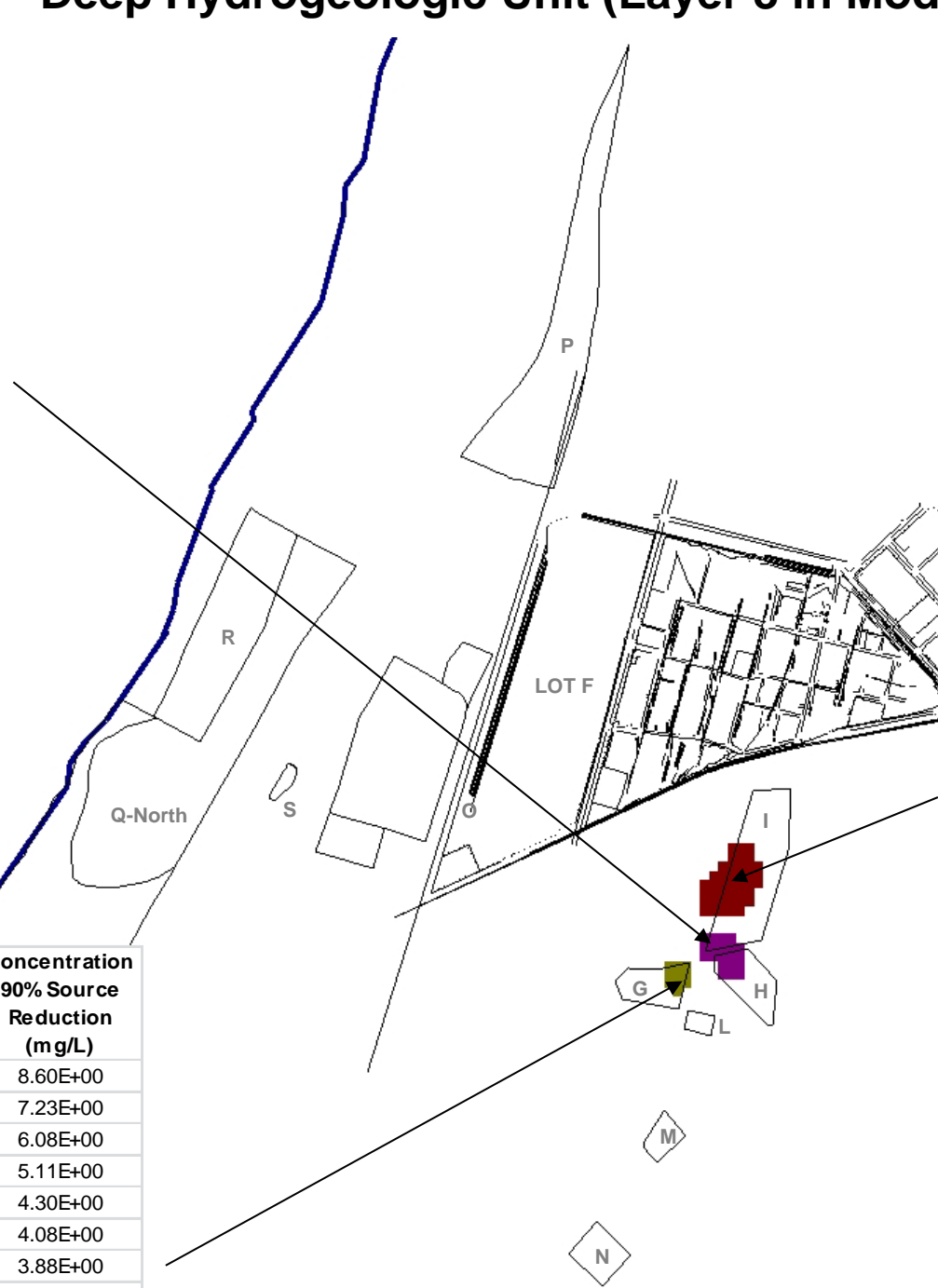| Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	8.60E+00	8.60E+00	8.60E+00	8.60E+00
6/1/1970	6/1/1980	7.23E+00	7.23E+00	7.23E+00	7.23E+00
6/1/1980	6/1/1990	6.08E+00	6.08E+00	6.08E+00	6.08E+00
6/1/1990	6/1/2000	5.11E+00	5.11E+00	5.11E+00	5.11E+00
6/1/2000	6/1/2003	4.30E+00	4.30E+00	4.30E+00	4.30E+00
6/1/2003	6/1/2006	4.08E+00	4.08E+00	4.08E+00	4.08E+00
6/1/2006	6/1/2010	3.88E+00	3.88E+00	3.88E+00	3.88E+00
6/1/2010	6/1/2015	3.62E+00	3.62E+00	3.62E+00	3.62E+00
6/1/2015	6/1/2020	3.32E+00	1.66E+00	8.29E-01	3.32E-01
6/1/2020	6/1/2030	3.04E+00	1.52E+00	7.60E-01	3.04E-01
6/1/2030	6/1/2038	2.56E+00	1.28E+00	6.39E-01	2.56E-01
6/1/2038	6/1/2040	2.23E+00	1.11E+00	5.56E-01	2.23E-01
6/1/2040	6/1/2050	2.15E+00	1.08E+00	5.38E-01	2.15E-01
6/1/2050	6/1/2060	1.81E+00	9.04E-01	4.52E-01	1.81E-01
6/1/2060	6/1/2070	1.52E+00	7.60E-01	3.80E-01	1.52E-01
6/1/2070	6/1/2080	1.28E+00	6.39E-01	3.20E-01	1.28E-01
6/1/2080	6/1/2090	1.08E+00	5.38E-01	2.69E-01	1.08E-01
6/1/2090	6/1/2100	9.04E-01	4.52E-01	2.26E-01	9.04E-02

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
3. Source reduction simulated in 2015.

FIGURE A.3
Chlorobenzene Source Areas and Concentrations
Deep Hydrogeologic Unit (Layer 3 in Model)

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	9.20E+00	9.20E+00	9.20E+00	9.20E+00
6/1/1970	6/1/1980	7.74E+00	7.74E+00	7.74E+00	7.74E+00
6/1/1980	6/1/1990	6.51E+00	6.51E+00	6.51E+00	6.51E+00
6/1/1990	6/1/2000	5.47E+00	5.47E+00	5.47E+00	5.47E+00
6/1/2000	6/1/2003	4.60E+00	4.60E+00	4.60E+00	4.60E+00
6/1/2003	6/1/2006	4.37E+00	4.37E+00	4.37E+00	4.37E+00
6/1/2006	6/1/2010	4.15E+00	4.15E+00	4.15E+00	4.15E+00
6/1/2010	6/1/2015	3.87E+00	3.87E+00	3.87E+00	3.87E+00
6/1/2015	6/1/2020	3.55E+00	1.77E+00	8.87E-01	3.55E-01
6/1/2020	6/1/2030	3.25E+00	1.63E+00	8.13E-01	3.25E-01
6/1/2030	6/1/2038	2.74E+00	1.37E+00	6.84E-01	2.74E-01
6/1/2038	6/1/2040	2.38E+00	1.19E+00	5.95E-01	2.38E-01
6/1/2040	6/1/2050	2.30E+00	1.15E+00	5.75E-01	2.30E-01
6/1/2050	6/1/2060	1.93E+00	9.67E-01	4.84E-01	1.93E-01
6/1/2060	6/1/2070	1.63E+00	8.13E-01	4.07E-01	1.63E-01
6/1/2070	6/1/2080	1.37E+00	6.84E-01	3.42E-01	1.37E-01
6/1/2080	6/1/2090	1.15E+00	5.75E-01	2.88E-01	1.15E-01
6/1/2090	6/1/2100	9.67E-01	4.84E-01	2.42E-01	9.67E-02

P

R

LOT F

Q-North

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	2.04E+02	2.04E+02	2.04E+02	2.04E+02
6/1/1970	6/1/1980	1.72E+02	1.72E+02	1.72E+02	1.72E+02
6/1/1980	6/1/1990	1.44E+02	1.44E+02	1.44E+02	1.44E+02
6/1/1990	6/1/2000	1.20E+02	1.20E+02	1.20E+02	1.20E+02
6/1/2000	6/1/2003	1.02E+02	1.02E+02	1.02E+02	1.02E+02
6/1/2003	6/1/2006	9.68E+01	9.68E+01	9.68E+01	9.68E+01
6/1/2006	6/1/2010	9.19E+01	9.19E+01	9.19E+01	9.19E+01
6/1/2010	6/1/2015	8.58E+01	8.58E+01	8.58E+01	8.58E+01
6/1/2015	6/1/2020	7.87E+01	3.93E+01	1.97E+01	7.87E+00
6/1/2020	6/1/2030	7.21E+01	3.61E+01	1.80E+01	7.21E+00
6/1/2030	6/1/2038	6.06E+01	3.03E+01	1.52E+01	6.06E+00
6/1/2038	6/1/2040	5.28E+01	2.64E+01	1.32E+01	5.28E+00
6/1/2040	6/1/2050	5.10E+01	2.55E+01	1.28E+01	5.10E+00
6/1/2050	6/1/2060	4.29E+01	2.14E+01	1.07E+01	4.29E+00
6/1/2060	6/1/2070	3.61E+01	1.80E+01	9.02E+00	3.61E+00
6/1/2070	6/1/2080	3.03E+01	1.52E+01	7.58E+00	3.03E+00
6/1/2080	6/1/2090	2.55E+01	1.28E+01	6.38E+00	2.55E+00
6/1/2090	6/1/2100	2.14E+01	1.07E+01	5.36E+00	2.14E+00

I

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	8.60E+00	8.60E+00	8.60E+00	8.60E+00
6/1/1970	6/1/1980	7.23E+00	7.23E+00	7.23E+00	7.23E+00
6/1/1980	6/1/1990	6.08E+00	6.08E+00	6.08E+00	6.08E+00
6/1/1990	6/1/2000	5.11E+00	5.11E+00	5.11E+00	5.11E+00
6/1/2000	6/1/2003	4.30E+00	4.30E+00	4.30E+00	4.30E+00
6/1/2003	6/1/2006	4.08E+00	4.08E+00	4.08E+00	4.08E+00
6/1/2006	6/1/2010	3.88E+00	3.88E+00	3.88E+00	3.88E+00
6/1/2010	6/1/2015	3.62E+00	3.62E+00	3.62E+00	3.62E+00
6/1/2015	6/1/2020	3.32E+00	1.66E+00	8.29E-01	3.32E-01
6/1/2020	6/1/2030	3.04E+00	1.52E+00	7.60E-01	3.04E-01
6/1/2030	6/1/2038	2.56E+00	1.28E+00	6.39E-01	2.56E-01
6/1/2038	6/1/2040	2.23E+00	1.11E+00	5.56E-01	2.23E-01
6/1/2040	6/1/2050	2.15E+00	1.08E+00	5.38E-01	2.15E-01
6/1/2050	6/1/2060	1.81E+00	9.04E-01	4.52E-01	1.81E-01
6/1/2060	6/1/2070	1.52E+00	7.60E-01	3.80E-01	1.52E-01
6/1/2070	6/1/2080	1.28E+00	6.39E-01	3.20E-01	1.28E-01
6/1/2080	6/1/2090	1.08E+00	5.38E-01	2.69E-01	1.08E-01
6/1/2090	6/1/2100	9.04E-01	4.52E-01	2.26E-01	9.04E-02

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
3. Source reduction simulated in 2015.

FIGURE A.4
1,4-Dichlorobenzene Source Areas and Concentrations
Shallow Hydrogeologic Unit (Layer 1 in Model)

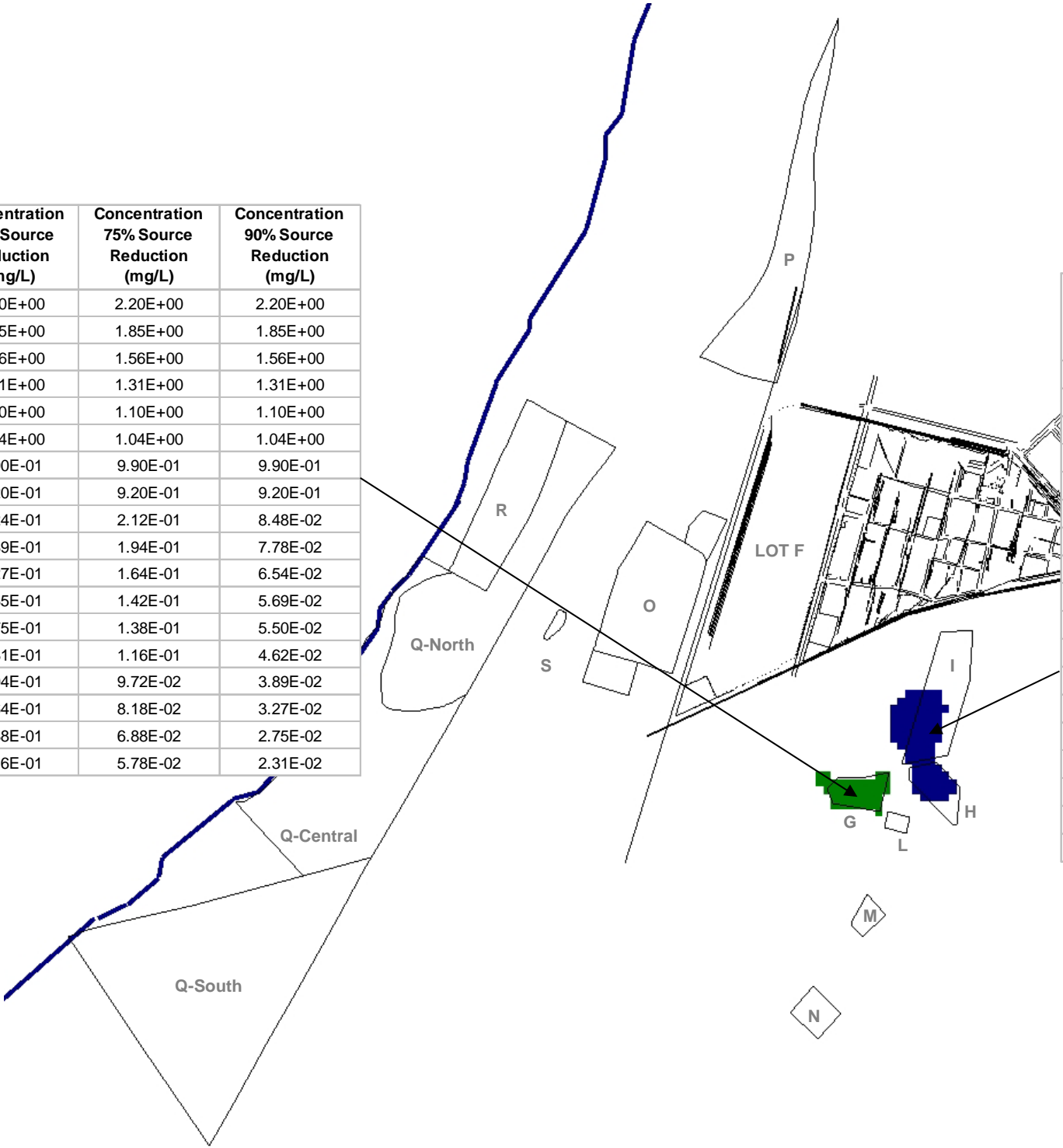GSI ENVIRONMENTAL

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	2.20E+00	2.20E+00	2.20E+00	2.20E+00
6/1/1970	6/1/1980	1.85E+00	1.85E+00	1.85E+00	1.85E+00
6/1/1980	6/1/1990	1.56E+00	1.56E+00	1.56E+00	1.56E+00
6/1/1990	6/1/2000	1.31E+00	1.31E+00	1.31E+00	1.31E+00
6/1/2000	6/1/2003	1.10E+00	1.10E+00	1.10E+00	1.10E+00
6/1/2003	6/1/2006	1.04E+00	1.04E+00	1.04E+00	1.04E+00
6/1/2006	6/1/2010	9.90E-01	9.90E-01	9.90E-01	9.90E-01
6/1/2010	6/1/2015	9.20E-01	9.20E-01	9.20E-01	9.20E-01
6/1/2015	6/1/2020	8.48E-01	4.24E-01	2.12E-01	8.48E-02
6/1/2020	6/1/2030	7.80E-01	3.89E-01	1.94E-01	7.78E-02
6/1/2030	6/1/2038	6.50E-01	3.27E-01	1.64E-01	6.54E-02
6/1/2038	6/1/2040	5.69E-01	2.85E-01	1.42E-01	5.69E-02
6/1/2040	6/1/2050	5.50E-01	2.75E-01	1.38E-01	5.50E-02
6/1/2050	6/1/2060	4.62E-01	2.31E-01	1.16E-01	4.62E-02
6/1/2060	6/1/2070	3.89E-01	1.94E-01	9.72E-02	3.89E-02
6/1/2070	6/1/2080	3.27E-01	1.64E-01	8.18E-02	3.27E-02
6/1/2080	6/1/2090	2.75E-01	1.38E-01	6.88E-02	2.75E-02
6/1/2090	6/1/2100	2.31E-01	1.16E-01	5.78E-02	2.31E-02

Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	7.40E+00	7.40E+00	7.40E+00	7.40E+00
6/1/1970	6/1/1980	6.22E+00	6.22E+00	6.22E+00	6.22E+00
6/1/1980	6/1/1990	5.23E+00	5.23E+00	5.23E+00	5.23E+00
6/1/1990	6/1/2000	4.40E+00	4.40E+00	4.40E+00	4.40E+00
6/1/2000	6/1/2003	3.70E+00	3.70E+00	3.70E+00	3.70E+00
6/1/2003	6/1/2006	3.51E+00	3.51E+00	3.51E+00	3.51E+00
6/1/2006	6/1/2010	3.33E+00	3.33E+00	3.33E+00	3.33E+00
6/1/2010	6/1/2015	3.11E+00	3.11E+00	3.11E+00	3.11E+00
6/1/2015	6/1/2020	2.85E+00	1.43E+00	7.13E-01	2.85E-01
6/1/2020	6/1/2030	2.62E+00	1.31E+00	6.54E-01	2.62E-01
6/1/2030	6/1/2038	2.20E+00	1.10E+00	5.50E-01	2.20E-01
6/1/2038	6/1/2040	1.92E+00	9.58E-01	4.79E-01	1.92E-01
6/1/2040	6/1/2050	1.85E+00	9.25E-01	4.63E-01	1.85E-01
6/1/2050	6/1/2060	1.56E+00	7.78E-01	3.89E-01	1.56E-01
6/1/2060	6/1/2070	1.31E+00	6.54E-01	3.27E-01	1.31E-01
6/1/2070	6/1/2080	1.10E+00	5.50E-01	2.75E-01	1.10E-01
6/1/2080	6/1/2090	9.25E-01	4.63E-01	2.31E-01	9.25E-02
6/1/2090	6/1/2100	7.78E-01	3.89E-01	1.94E-01	7.78E-02

Map labels: P, R, LOT F, O, Q-North, S, Q-Central, Q-South, G, L, H, I, M, N

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
3. Source reduction simulated in 2015.

FIGURE A.5
1,4-Dichlorobenzene Source Areas and Concentrations
Middle Hydrogeologic Unit (Layer 2 in Model)
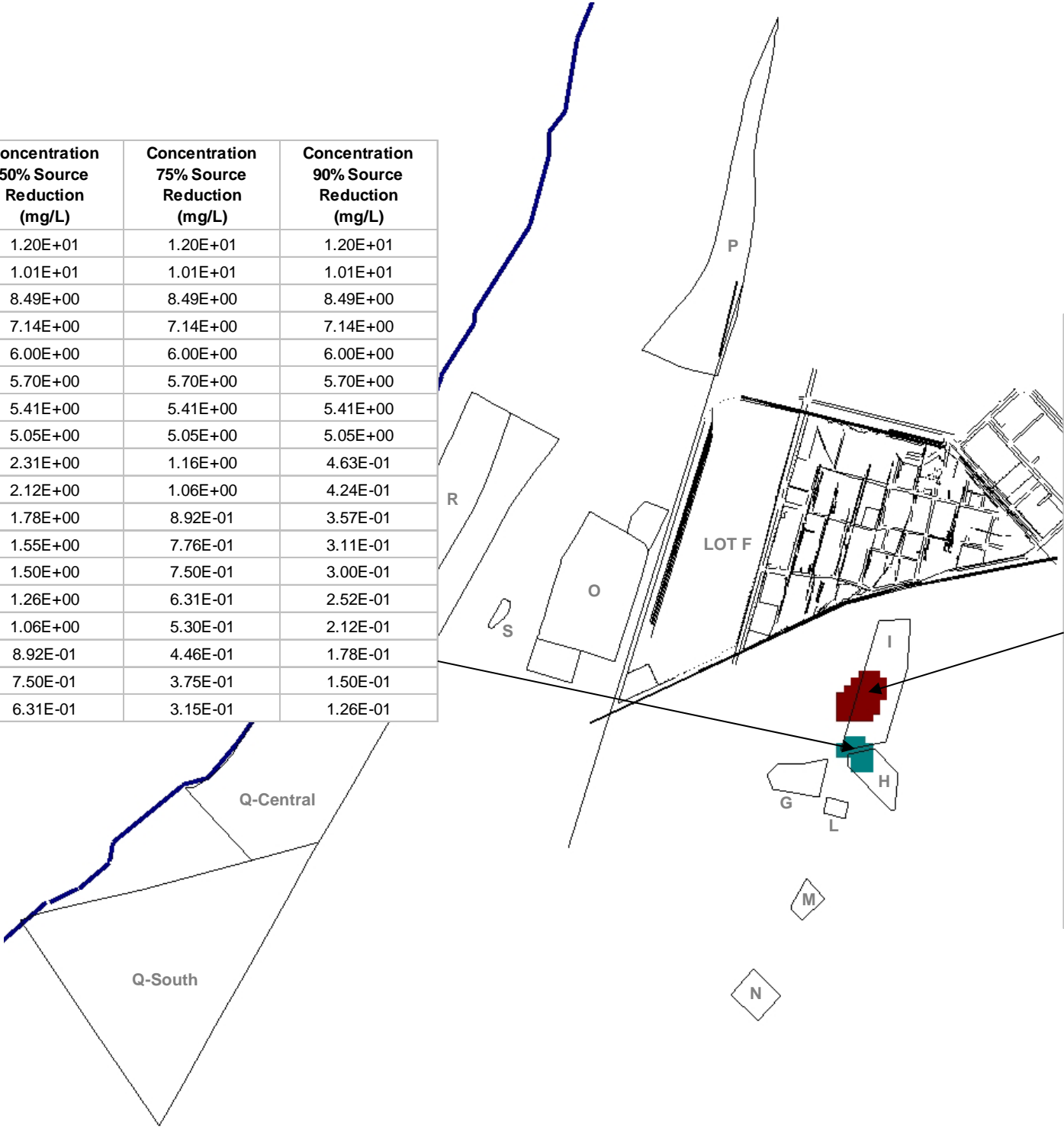
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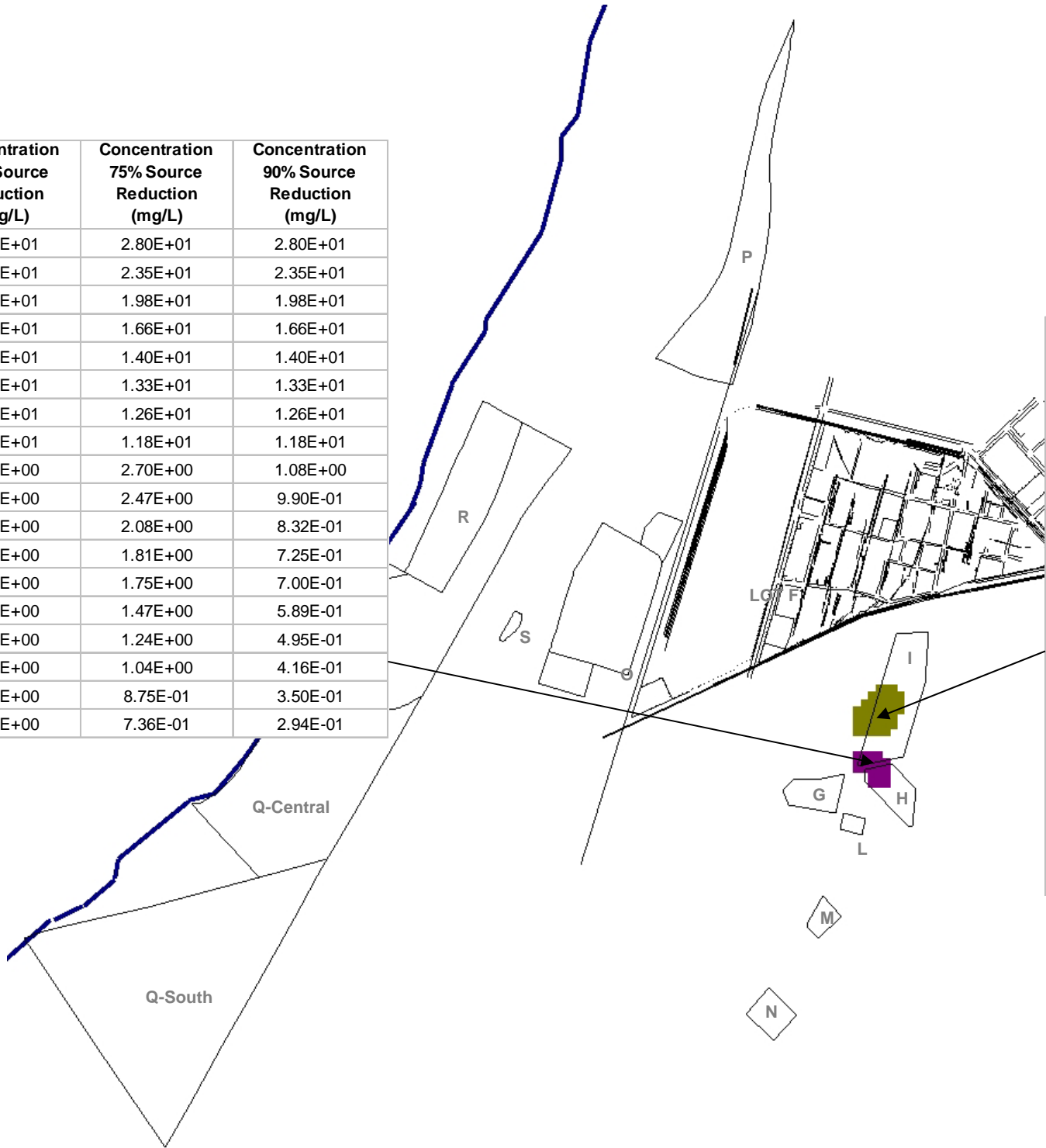| Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	1.20E+01	1.20E+01	1.20E+01	1.20E+01
6/1/1970	6/1/1980	1.01E+01	1.01E+01	1.01E+01	1.01E+01
6/1/1980	6/1/1990	8.49E+00	8.49E+00	8.49E+00	8.49E+00
6/1/1990	6/1/2000	7.14E+00	7.14E+00	7.14E+00	7.14E+00
6/1/2000	6/1/2003	6.00E+00	6.00E+00	6.00E+00	6.00E+00
6/1/2003	6/1/2006	5.70E+00	5.70E+00	5.70E+00	5.70E+00
6/1/2006	6/1/2010	5.41E+00	5.41E+00	5.41E+00	5.41E+00
6/1/2010	6/1/2015	5.05E+00	5.05E+00	5.05E+00	5.05E+00
6/1/2015	6/1/2020	4.63E+00	2.31E+00	1.16E+00	4.63E-01
6/1/2020	6/1/2030	4.24E+00	2.12E+00	1.06E+00	4.24E-01
6/1/2030	6/1/2038	3.57E+00	1.78E+00	8.92E-01	3.57E-01
6/1/2038	6/1/2040	3.11E+00	1.55E+00	7.76E-01	3.11E-01
6/1/2040	6/1/2050	3.00E+00	1.50E+00	7.50E-01	3.00E-01
6/1/2050	6/1/2060	2.52E+00	1.26E+00	6.31E-01	2.52E-01
6/1/2060	6/1/2070	2.12E+00	1.06E+00	5.30E-01	2.12E-01
6/1/2070	6/1/2080	1.78E+00	8.92E-01	4.46E-01	1.78E-01
6/1/2080	6/1/2090	1.50E+00	7.50E-01	3.75E-01	1.50E-01
6/1/2090	6/1/2100	1.26E+00	6.31E-01	3.15E-01	1.26E-01

Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	2.80E+01	2.80E+01	2.80E+01	2.80E+01
6/1/1970	6/1/1980	2.35E+01	2.35E+01	2.35E+01	2.35E+01
6/1/1980	6/1/1990	1.98E+01	1.98E+01	1.98E+01	1.98E+01
6/1/1990	6/1/2000	1.67E+01	1.67E+01	1.67E+01	1.67E+01
6/1/2000	6/1/2003	1.40E+01	1.40E+01	1.40E+01	1.40E+01
6/1/2003	6/1/2006	1.33E+01	1.33E+01	1.33E+01	1.33E+01
6/1/2006	6/1/2010	1.26E+01	1.26E+01	1.26E+01	1.26E+01
6/1/2010	6/1/2015	1.18E+01	1.18E+01	1.18E+01	1.18E+01
6/1/2015	6/1/2020	1.08E+01	5.40E+00	2.70E+00	1.08E+00
6/1/2020	6/1/2030	9.90E+00	4.95E+00	2.47E+00	9.90E-01
6/1/2030	6/1/2038	8.32E+00	4.16E+00	2.08E+00	8.32E-01
6/1/2038	6/1/2040	7.25E+00	3.62E+00	1.81E+00	7.25E-01
6/1/2040	6/1/2050	7.00E+00	3.50E+00	1.75E+00	7.00E-01
6/1/2050	6/1/2060	5.89E+00	2.94E+00	1.47E+00	5.89E-01
6/1/2060	6/1/2070	4.95E+00	2.47E+00	1.24E+00	4.95E-01
6/1/2070	6/1/2080	4.16E+00	2.08E+00	1.04E+00	4.16E-01
6/1/2080	6/1/2090	3.50E+00	1.75E+00	8.75E-01	3.50E-01
6/1/2090	6/1/2100	2.94E+00	1.47E+00	7.36E-01	2.94E-01

Map labels: P, R, LOT F, O, S, I, H, G, L, M, N, Q-Central, Q-South

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
3. Source reduction simulated in 2015.

FIGURE A.6
1,4-Dichlorobenzene Source Areas and Concentrations
Deep Hydrogeologic Unit (Layer 3 in Model)

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Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	2.80E+01	2.80E+01	2.80E+01	2.80E+01
6/1/1970	6/1/1980	2.35E+01	2.35E+01	2.35E+01	2.35E+01
6/1/1980	6/1/1990	1.98E+01	1.98E+01	1.98E+01	1.98E+01
6/1/1990	6/1/2000	1.66E+01	1.66E+01	1.66E+01	1.66E+01
6/1/2000	6/1/2003	1.40E+01	1.40E+01	1.40E+01	1.40E+01
6/1/2003	6/1/2006	1.33E+01	1.33E+01	1.33E+01	1.33E+01
6/1/2006	6/1/2010	1.26E+01	1.26E+01	1.26E+01	1.26E+01
6/1/2010	6/1/2015	1.18E+01	1.18E+01	1.18E+01	1.18E+01
6/1/2015	6/1/2020	1.08E+01	5.40E+00	2.70E+00	1.08E+00
6/1/2020	6/1/2030	9.90E+00	4.95E+00	2.47E+00	9.90E-01
6/1/2030	6/1/2038	8.32E+00	4.16E+00	2.08E+00	8.32E-01
6/1/2038	6/1/2040	7.25E+00	3.62E+00	1.81E+00	7.25E-01
6/1/2040	6/1/2050	7.00E+00	3.50E+00	1.75E+00	7.00E-01
6/1/2050	6/1/2060	5.89E+00	2.94E+00	1.47E+00	5.89E-01
6/1/2060	6/1/2070	4.95E+00	2.47E+00	1.24E+00	4.95E-01
6/1/2070	6/1/2080	4.16E+00	2.08E+00	1.04E+00	4.16E-01
6/1/2080	6/1/2090	3.50E+00	1.75E+00	8.75E-01	3.50E-01
6/1/2090	6/1/2100	2.94E+00	1.47E+00	7.36E-01	2.94E-01

Start Date	End Date	Concentration MNA (mg/L)	Concentration 50% Source Reduction (mg/L)	Concentration 75% Source Reduction (mg/L)	Concentration 90% Source Reduction (mg/L)
6/1/1960	6/1/1970	1.63E+01	1.63E+01	1.63E+01	1.63E+01
6/1/1970	6/1/1980	1.37E+01	1.37E+01	1.37E+01	1.37E+01
6/1/1980	6/1/1990	1.15E+01	1.15E+01	1.15E+01	1.15E+01
6/1/1990	6/1/2000	9.70E+00	9.70E+00	9.70E+00	9.70E+00
6/1/2000	6/1/2003	8.16E+00	8.16E+00	8.16E+00	8.16E+00
6/1/2003	6/1/2006	7.74E+00	7.74E+00	7.74E+00	7.74E+00
6/1/2006	6/1/2010	7.35E+00	7.35E+00	7.35E+00	7.35E+00
6/1/2010	6/1/2015	6.86E+00	6.86E+00	6.86E+00	6.86E+00
6/1/2015	6/1/2020	6.29E+00	3.14E+00	1.57E+00	6.29E-01
6/1/2020	6/1/2030	5.77E+00	2.88E+00	1.44E+00	5.77E-01
6/1/2030	6/1/2038	4.85E+00	2.42E+00	1.21E+00	4.85E-01
6/1/2038	6/1/2040	4.22E+00	2.11E+00	1.06E+00	4.22E-01
6/1/2040	6/1/2050	4.08E+00	2.04E+00	1.02E+00	4.08E-01
6/1/2050	6/1/2060	3.43E+00	1.71E+00	8.57E-01	3.43E-01
6/1/2060	6/1/2070	2.88E+00	1.44E+00	7.21E-01	2.88E-01
6/1/2070	6/1/2080	2.42E+00	1.21E+00	6.06E-01	2.42E-01
6/1/2080	6/1/2090	2.04E+00	1.02E+00	5.10E-01	2.04E-01
6/1/2090	6/1/2100	1.71E+00	8.57E-01	4.29E-01	1.71E-01

NOTES:
1. Colored region represents the final source area assigned in the transport model. All concentrations in mg/L.
2. Site basemap from: "Remedial Investigation/Feasibility Study Report Sauget Area 2", URS Corporation, St. Louis, Missouri, January 30, 2004.
3. Source reduction simulated in 2015.

TIME TO CLEAN ESTIMATES
Sauget Area 1, Sauget, Illinois

APPENDIX B
COMPARISON OF MODELED RESULTS TO EXISTING PLUME MAPS

Comparison of Modeled Results to Existing Plume Maps

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COMPARISON OF MODELED RESULTS TO EXISTING PLUME MAPS
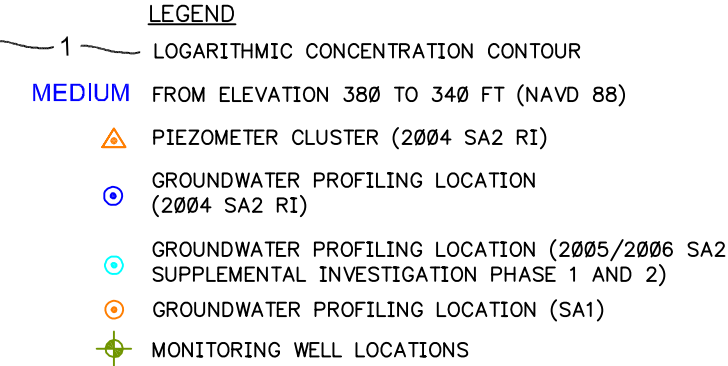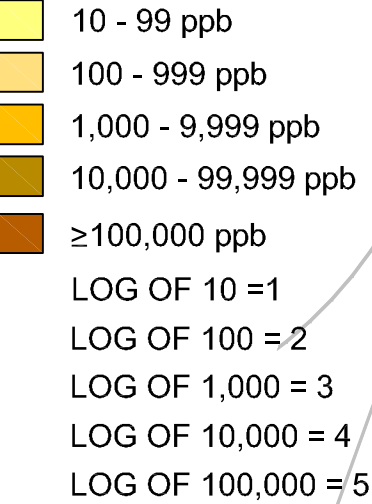Sauget Area 1, Sauget and Cahokia, Illinois

Modeled results were compared to measured concentrations at sampling location UAA-2, which is at approximately the same location as the modeled observation well (i.e., mid way between Site I and the Mississippi River). Measured concentrations are shown on the MHU and DHU plume maps for chlorobenzene (CB) and 1,4-dichlorobenzene (1,4-DCB) from the Remedial Investigation Report (see attached Figures 5-25, 5-26, 5-28, and 5-29).

In the MHU, the measured concentrations of CB and 1,4-DCB at UAA-2 were 81 ug/L and <10 ug/L, which are below the respective MCLs and are significantly below the predicted concentrations for 2006. Therefore, for the MHU, the model over predicts the CB and 1,4-DCB concentrations at the downgradient observation well.

In the DHU, the measured concentrations of CB and 1,4-DCB at UUA-2 were 2600 ug/L and 1200 ug/L, respectively, which are comparable to the modeled concentrations for 2006. This suggests that the model provides a good representation of CB and 1,4-DCB concentrations in the DHU downgradient of SA1.

CONTOUR LEGEND

- ☐ 10 - 99 ppb
- ☐ 100 - 999 ppb
- ☐ 1,000 - 9,999 ppb
- ☐ 10,000 - 99,999 ppb
- ☐ ≥100,000 ppb

LOG OF 10 = 1
LOG OF 100 = 2
LOG OF 1,000 = 3
LOG OF 10,000 = 4
LOG OF 100,000 = 5

LEGEND

— 1 — LOGARITHMIC CONCENTRATION CONTOUR

MEDIUM FROM ELEVATION 380 TO 340 FT (NAVD 88)

△ PIEZOMETER CLUSTER (2004 SA2 RI)

⊙ GROUNDWATER PROFILING LOCATION
(2004 SA2 RI)

⊙ GROUNDWATER PROFILING LOCATION (2005/2006 SA2
SUPPLEMENTAL INVESTIGATION PHASE 1 AND 2)

⊙ GROUNDWATER PROFILING LOCATION (SA1)

✦ MONITORING WELL LOCATIONS

NOTES:

A) CONSTITUENT CONCENTRATIONS GREATER THAN THE LABORATORY REPORTING LIMIT CORRESPONDING TO EACH LOCATION ARE PRESENTED IN BLUE NEXT TO THE SAMPLE LOCATION. AT SAMPLING LOCATIONS WITH NON-DETECT RESULTS, CONCENTRATIONS ARE GIVEN AS < REPORTING LIMIT AND SHOWN IN GREEN. FOR THOSE LOCATIONS WITH NON-DETECT RESULTS AT A LABORATORY REPORTING LIMIT LESS THAN OR EQUAL TO 5 ppb, 1/2 OF THE REPORTING LIMIT WAS USED TO GENERATE THE CONCENTRATION CONTOURS. NON-DETECT LABORATORY RESULTS HAVING A REPORTING LIMIT GREATER THAN 5 ppb WERE NOT USED TO GENERATE THE CONCENTRATION CONTOURS.

B) LOCATIONS THAT ARE GREY SCALED ARE LOCATED WITHIN THIS HYDROLOGIC UNIT, BUT WERE NOT SAMPLED.

C) THE BASE-10 LOGARITHM OF EACH CONCENTRATION WAS USED TO GENERATE THE CONTOUR LINES.

D) PRELIMINARY, SOFTWARE-GENERATED DRAFT. EDITED BASED ON PROFESSIONAL JUDGEMENT.

E) AT LOCATIONS WITH MULTIPLE SAMPLES, THE HIGHEST CONCENTRATION WAS USED.

SAUGET AREA 1
REMEDIAL INVESTIGATION REPORT
SAUGET AND CAHOKIA, ILLINOIS

PROJECT NO.
21562123

URS

DRN. BY: lrm 6/11/09
DSGN. BY: ekf
CHKD. BY:

Chlorobenzene
Isoconcentration Map-MHU

FIG. NO.
5-25
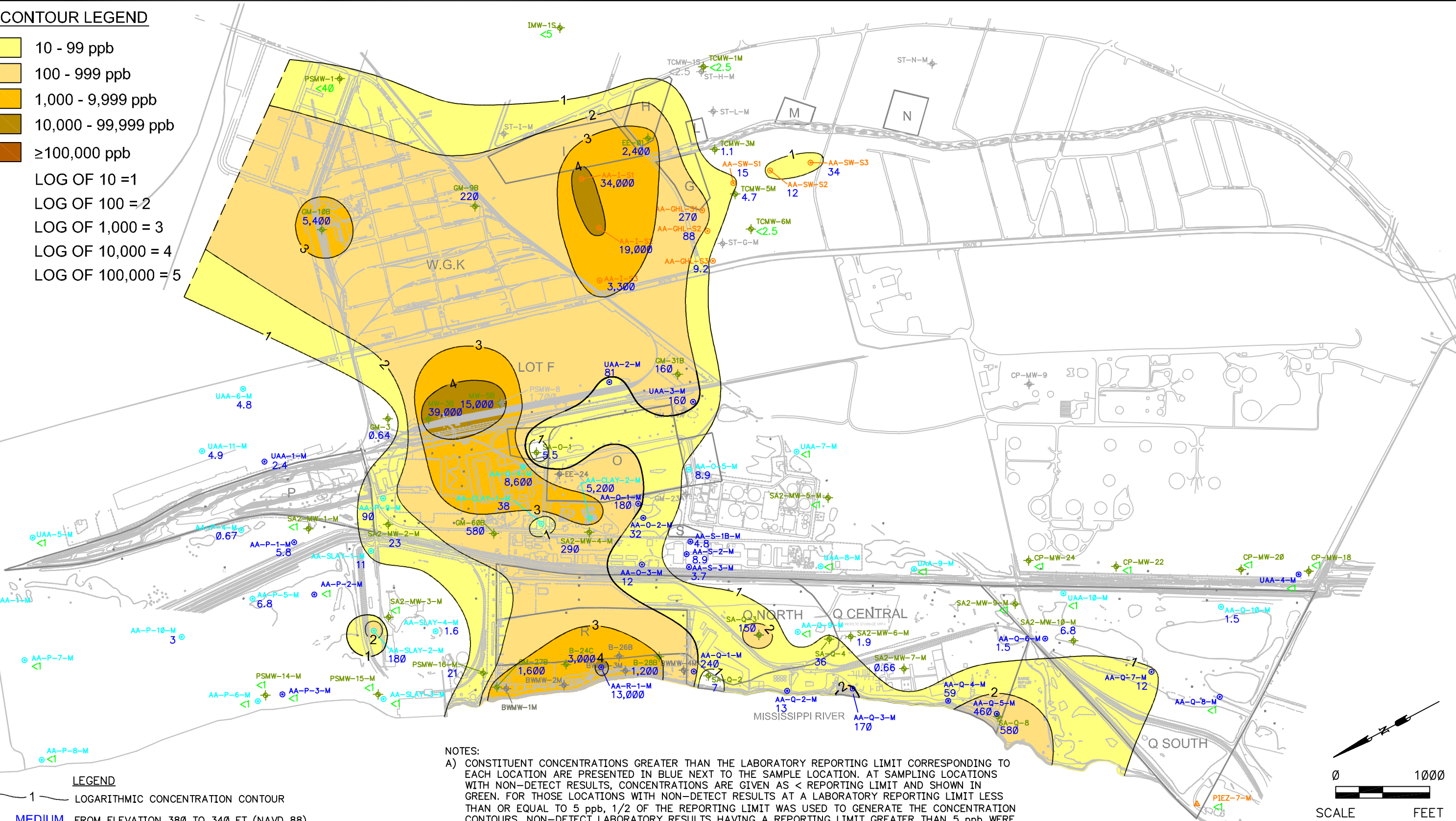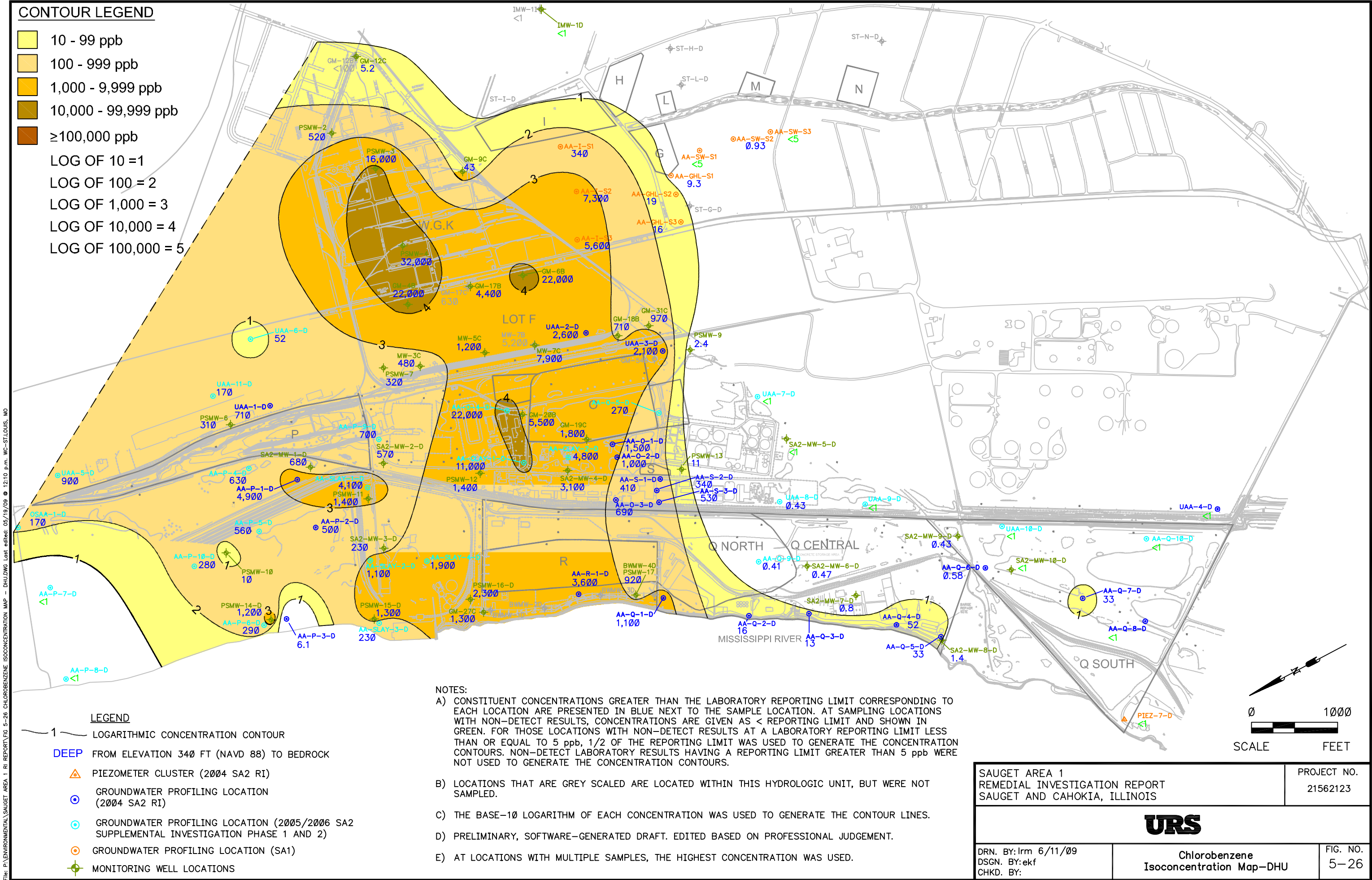
File: P:\ENVIRONMENTAL\SAUGET AREA 1 RI REPORT\FIG 5-25 CHLOROBENZENE ISOCONCENTRATION MAP - MHU.DWG Last edited: 05/19/09 @ 12:08 p.m. WC-ST.LOUIS, MO

Figure 5-26. Chlorobenzene Isoconcentration Map—DHU

CONTOUR LEGEND

- 10 - 99 ppb
- 100 - 999 ppb
- 1,000 - 9,999 ppb
- 10,000 - 99,999 ppb
- ≥100,000 ppb

LOG OF 10 = 1
LOG OF 100 = 2
LOG OF 1,000 = 3
LOG OF 10,000 = 4
LOG OF 100,000 = 5

LEGEND

1 —— LOGARITHMIC CONCENTRATION CONTOUR

DEEP FROM ELEVATION 340 FT (NAVD 88) TO BEDROCK

△ PIEZOMETER CLUSTER (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2005/2006 SA2 SUPPLEMENTAL INVESTIGATION PHASE 1 AND 2)

◉ GROUNDWATER PROFILING LOCATION (SA1)

✛ MONITORING WELL LOCATIONS

NOTES:

A) CONSTITUENT CONCENTRATIONS GREATER THAN THE LABORATORY REPORTING LIMIT CORRESPONDING TO EACH LOCATION ARE PRESENTED IN BLUE NEXT TO THE SAMPLE LOCATION. AT SAMPLING LOCATIONS WITH NON-DETECT RESULTS, CONCENTRATIONS ARE GIVEN AS < REPORTING LIMIT AND SHOWN IN GREEN. FOR THOSE LOCATIONS WITH NON-DETECT RESULTS AT A LABORATORY REPORTING LIMIT LESS THAN OR EQUAL TO 5 ppb, 1/2 OF THE REPORTING LIMIT WAS USED TO GENERATE THE CONCENTRATION CONTOURS. NON-DETECT LABORATORY RESULTS HAVING A REPORTING LIMIT GREATER THAN 5 ppb WERE NOT USED TO GENERATE THE CONCENTRATION CONTOURS.

B) LOCATIONS THAT ARE GREY SCALED ARE LOCATED WITHIN THIS HYDROLOGIC UNIT, BUT WERE NOT SAMPLED.

C) THE BASE-10 LOGARITHM OF EACH CONCENTRATION WAS USED TO GENERATE THE CONTOUR LINES.

D) PRELIMINARY, SOFTWARE-GENERATED DRAFT. EDITED BASED ON PROFESSIONAL JUDGEMENT.

E) AT LOCATIONS WITH MULTIPLE SAMPLES, THE HIGHEST CONCENTRATION WAS USED.

SAUGET AREA 1
REMEDIAL INVESTIGATION REPORT
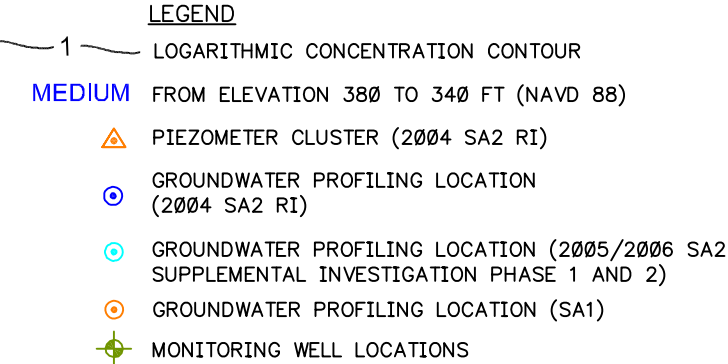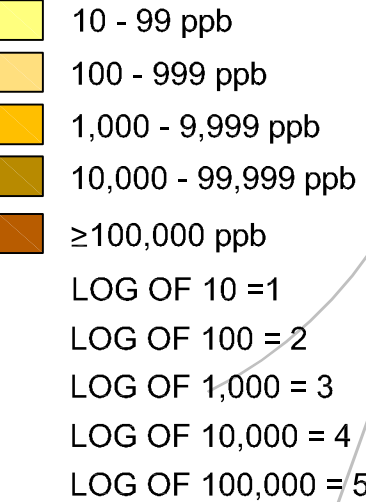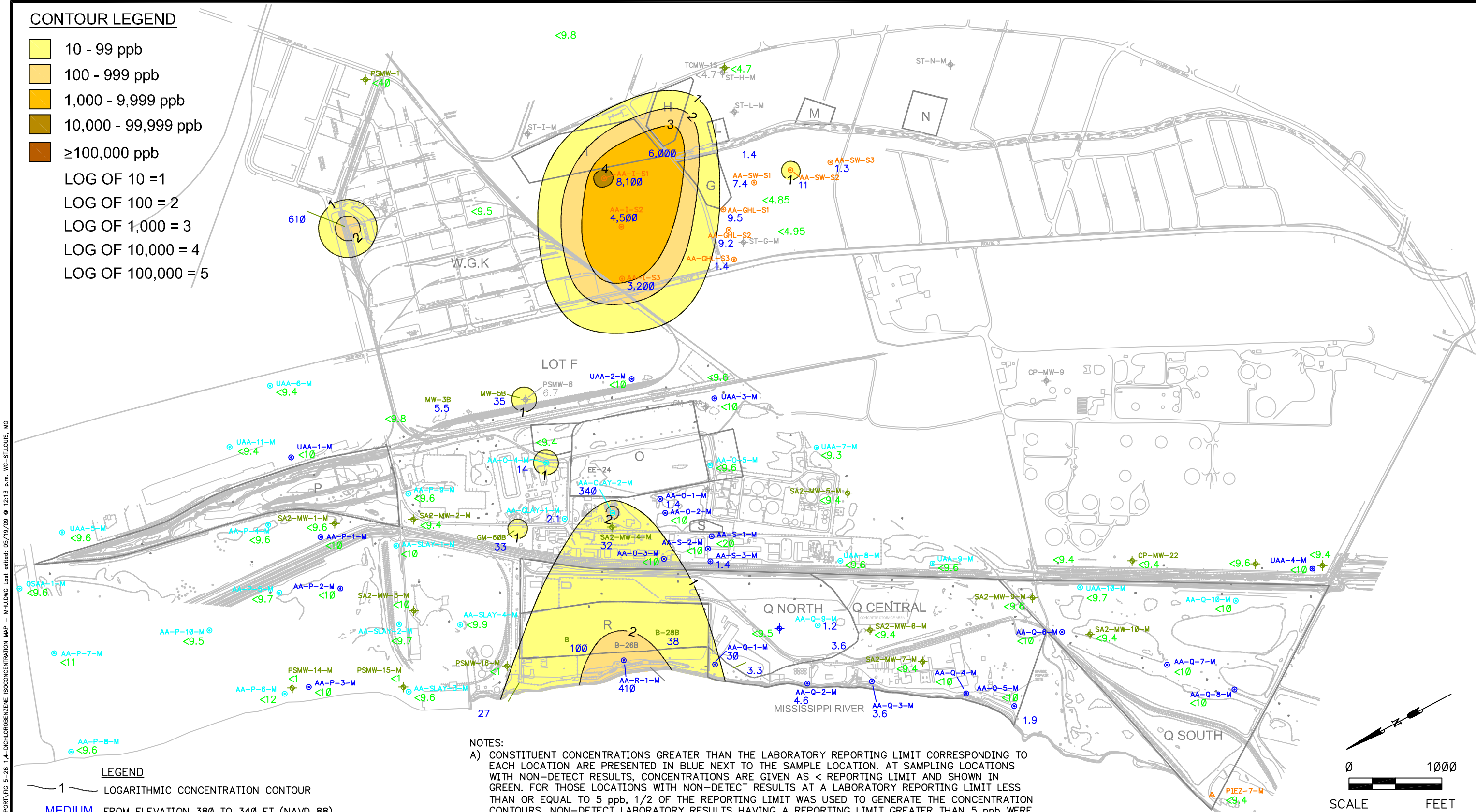SAUGET AND CAHOKIA, ILLINOIS

PROJECT NO. 21562123

DRN. BY: lrm 6/11/09
DSGN. BY: ekf
CHKD. BY:

URS

Chlorobenzene
Isoconcentration Map-DHU

FIG. NO. 5-26

SCALE FEET
0 1000

CONTOUR LEGEND

- 🟨 10 - 99 ppb
- 🟧 100 - 999 ppb
- 🟧 1,000 - 9,999 ppb
- 🟫 10,000 - 99,999 ppb
- 🟫 ≥100,000 ppb

LOG OF 10 = 1
LOG OF 100 = 2
LOG OF 1,000 = 3
LOG OF 10,000 = 4
LOG OF 100,000 = 5

LEGEND

— 1 — LOGARITHMIC CONCENTRATION CONTOUR

MEDIUM FROM ELEVATION 380 TO 340 FT (NAVD 88)

△ PIEZOMETER CLUSTER (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2005/2006 SA2 SUPPLEMENTAL INVESTIGATION PHASE 1 AND 2)

◉ GROUNDWATER PROFILING LOCATION (SA1)

✦ MONITORING WELL LOCATIONS

NOTES:

A) CONSTITUENT CONCENTRATIONS GREATER THAN THE LABORATORY REPORTING LIMIT CORRESPONDING TO EACH LOCATION ARE PRESENTED IN BLUE NEXT TO THE SAMPLE LOCATION. AT SAMPLING LOCATIONS WITH NON-DETECT RESULTS, CONCENTRATIONS ARE GIVEN AS < REPORTING LIMIT AND SHOWN IN GREEN. FOR THOSE LOCATIONS WITH NON-DETECT RESULTS AT A LABORATORY REPORTING LIMIT LESS THAN OR EQUAL TO 5 ppb, 1/2 OF THE REPORTING LIMIT WAS USED TO GENERATE THE CONCENTRATION CONTOURS. NON-DETECT LABORATORY RESULTS HAVING A REPORTING LIMIT GREATER THAN 5 ppb WERE NOT USED TO GENERATE THE CONCENTRATION CONTOURS.

B) LOCATIONS THAT ARE GREY SCALED ARE LOCATED WITHIN THIS HYDROLOGIC UNIT, BUT WERE NOT SAMPLED.

C) THE BASE-10 LOGARITHM OF EACH CONCENTRATION WAS USED TO GENERATE THE CONTOUR LINES.

D) PRELIMINARY, SOFTWARE-GENERATED DRAFT. EDITED BASED ON PROFESSIONAL JUDGEMENT.

E) AT LOCATIONS WITH MULTIPLE SAMPLES, THE HIGHEST CONCENTRATION WAS USED.

SCALE: 0 — 1000 FEET

SAUGET AREA 1
REMEDIAL INVESTIGATION REPORT
SAUGET AND CAHOKIA, ILLINOIS

PROJECT NO. 21562123
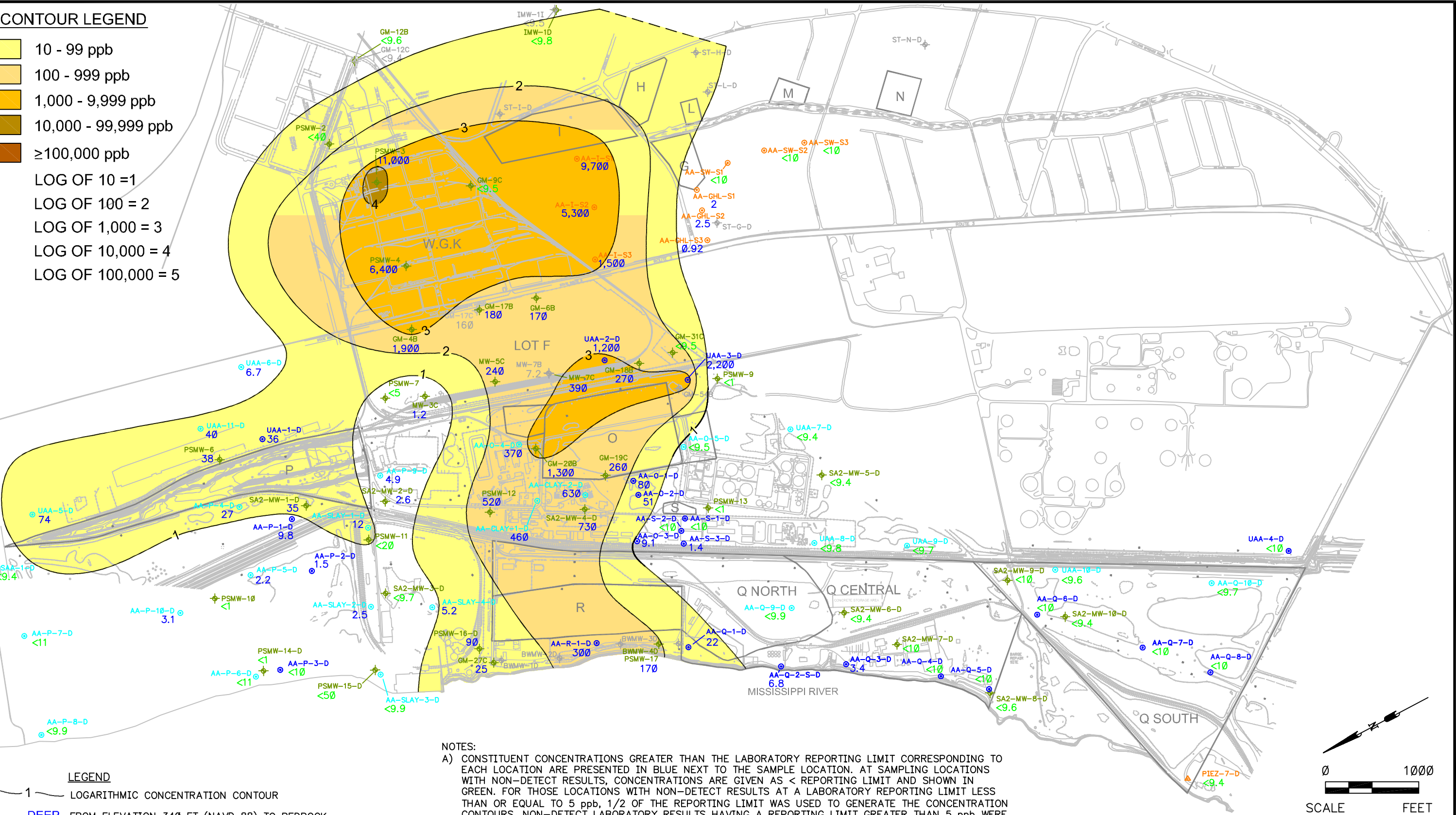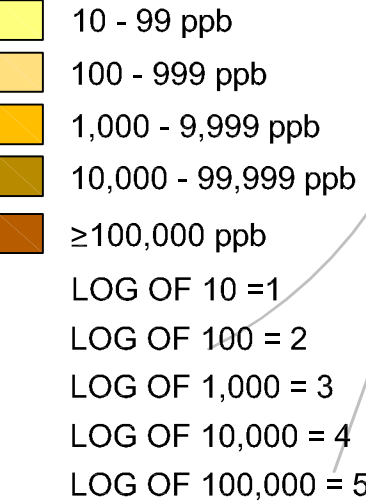
URS

DRN. BY: lrm 6/11/09
DSGN. BY: ekf
CHKD. BY:

1,4-Dichlorobenzene
Isoconcentration Map-MHU

FIG. NO. 5-28

CONTOUR LEGEND

- 10 - 99 ppb
- 100 - 999 ppb
- 1,000 - 9,999 ppb
- 10,000 - 99,999 ppb
- ≥100,000 ppb

LOG OF 10 = 1
LOG OF 100 = 2
LOG OF 1,000 = 3
LOG OF 10,000 = 4
LOG OF 100,000 = 5

LEGEND

1 — LOGARITHMIC CONCENTRATION CONTOUR

DEEP FROM ELEVATION 340 FT (NAVD 88) TO BEDROCK

△ PIEZOMETER CLUSTER (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2004 SA2 RI)

◉ GROUNDWATER PROFILING LOCATION (2005/2006 SA2 SUPPLEMENTAL INVESTIGATION PHASE 1 AND 2)

◉ GROUNDWATER PROFILING LOCATION (SA1)

✛ MONITORING WELL LOCATIONS

NOTES:

A) CONSTITUENT CONCENTRATIONS GREATER THAN THE LABORATORY REPORTING LIMIT CORRESPONDING TO EACH LOCATION ARE PRESENTED IN BLUE NEXT TO THE SAMPLE LOCATION. AT SAMPLING LOCATIONS WITH NON-DETECT RESULTS, CONCENTRATIONS ARE GIVEN AS < REPORTING LIMIT AND SHOWN IN GREEN. FOR THOSE LOCATIONS WITH NON-DETECT RESULTS AT A LABORATORY REPORTING LIMIT LESS THAN OR EQUAL TO 5 ppb, 1/2 OF THE REPORTING LIMIT WAS USED TO GENERATE THE CONCENTRATION CONTOURS. NON-DETECT LABORATORY RESULTS HAVING A REPORTING LIMIT GREATER THAN 5 ppb WERE NOT USED TO GENERATE THE CONCENTRATION CONTOURS.

B) LOCATIONS THAT ARE GREY SCALED ARE LOCATED WITHIN THIS HYDROLOGIC UNIT, BUT WERE NOT SAMPLED.

C) THE BASE-10 LOGARITHM OF EACH CONCENTRATION WAS USED TO GENERATE THE CONTOUR LINES.

D) PRELIMINARY, SOFTWARE-GENERATED DRAFT. EDITED BASED ON PROFESSIONAL JUDGEMENT.

E) AT LOCATIONS WITH MULTIPLE SAMPLES, THE HIGHEST CONCENTRATION WAS USED.

SCALE

0   1000   FEET

File: P:\ENVIRONMENTAL\SAUGET AREA 1 RI REPORT\FIG 5-29 1,4-DICHLOROBENZENE ISOCONCENTRATION MAP - DHU.DWG Last edited: 05/19/09 @ 12:14 p.m. WC-ST.LOUIS, MO